CHAPTER 11

FINLAND

11.1 GOVERNMENT PROGRAMS

11.1.1 Aims and Objectives

The Finnish government published a new energy strategy in 1997. In this strategy, the role of renewable energy is stressed. However, because unemployment in Finland is still high, energy politics is dominated by the wish for economic development. Thus, economic arguments dominate and environmental discussions such as the international discussions of CO_2 emissions, while recognized, are considered of less importance.

Renewable energy has, in general, good support in national energy politics, but the interest is focused on the use of bioenergy, especially wood or other residue from the forest industry. Wind energy is considered less significant. Wind energy has local support in some areas but only on the Åland islands has such support been transformed into a real political issue.

Wind energy is still seen only as a marginal energy resource, which could reach a level of "some" percent of energy production only after 2015.

11.1.2 Strategy and Targets

Wind energy has been supported by a specific wind energy action program since 1993, that aimed at having 100 MW of installed capacity by the year 2005. The main actions in this program have been an investment subsidy and a national energy research program. This action program will be reformulated into a general support program for renewable energy that will be based on the national energy policy document and the European Union White Paper on renewable energy. The activity to reformulate existing development programs has started and will be presented to the government during the spring of 1999.

11.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

11.2.1 Installed Wind Capacity

Beginning in 1997, there was evidence of a new start for wind energy development in Finland. The trend continued in 1998 with 5.6 MW of new capacity installed, a growth rate of 47%. Wind energy has also attracted several newcomers among power and energy companies. See Table 11.1.

Wind energy activities seem to be concentrated in three different regions. In the autonomous region of the Åland islands in the Southwest, development is focused around a specific wind energy co-operative with more than 2,000 shareholders and significant local support. Although, the

Table 11.1 Installed Capacity and Production of Wind Energy in Finland

YEAR	NEW CAPACITY (MW)	TOTAL CAPACITY (MW)	PRODUCTION (GWh)
1992	-	1.6	2.4
1993	3.0	4.6	4.4
1994	-	4.6	7.2
1995	1.8	6.4	10.8
1996	0.9	7.2	11.0
1997	4.6	11.8	16.6
1998	5.6	17.4	23.5

co-operative does not own all the turbines installed, it is nonetheless the dominant player in the region.

In the area around the northern part of the Gulf of Bothnia, several players are active. The most significant is a utility with a clear strategy to develop wind energy "step-by-step." The 1.2 MW turbine installed this year is already the third initiative of the utility. As the utility is clearly committed, the interest has spread to the neighboring municipalities and utilities which are taking action.

The third area with significant wind energy activity is Lapland in northern Finland. Here the power company Kemijoki is developing both technology and its own strategies to have a significant share of wind energy in the future. See Figure 11.1.

11.2.2 Comparison With Gross Electricity Consumption

The annual gross power consumption rose in 1997 to 73 TWh. The annual growth is expected to be about 2–4% for the next few decades. The current power production capacity during years with normal rainfall amounts to about 75 TWh.

11.2.3 Numbers, type and ownership of machines

Nine new turbines were installed in Finland during 1998 bringing the total number to 40. All installations are single turbines or small groups of up to four turbines. Most turbines, so far, are owned by power companies, utilities, or companies partly owned by utilities. Still, a large share is owned by co-operatives or specific wind energy companies. See Table 11.2.

11.2.4 Performance and Operational Experience

For wind energy, 1998 was not a good year. Annual production rose quite modestly to 23.5 MWh despite the rapid growth in capacity during the last two years.

Turbines in standard operation had an average availability of 94% in 1998. Several turbines suffered long downtime periods due to gearbox and generator

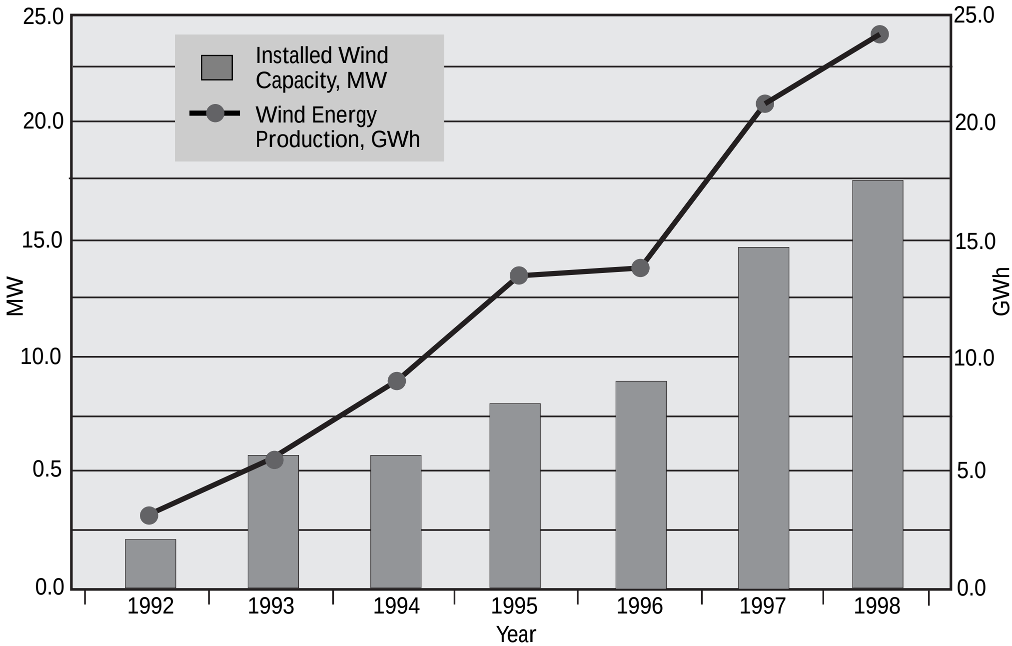

Figure 11.1 Installed Wind Energy Capacity in Finland

Table 11.2 Number of New Wind Turbines in Finland Installed Each Year

YEAR	<100 kW	200–300 kW	450–600 kW	750 kW and above	TOTAL
1991	1	4			5
1992		1			6
1993		11			17
1994					17
1995			4		21
1996			2		23
1997			8		31
1998			6	3	40

breakdowns. The specific ice-preventing equipment that is necessary in northernmost Finland has been modified on some of the turbines operating under especially harsh conditions. In addition, some of the turbines are not operated under complete commercial terms but are undergoing testing of materials and components and therefore have slightly lower performance.

11.3 MANUFACTURING INDUSTRY

11.3.1 Status of Manufacturing Industry

There are no wind turbine manufacturers in Finland. However, main components such as gearboxes and induction generators are produced and sold to the main wind turbine manufacturers. Also materials like steel plates and glass-fibre are sold to the wind industry. The total turnover of this “sale of components” is estimated at about FIM 400 million in 1998. The sales have increased steadily during the 90s.

The industry has been very successful in supplying components to medium-sized wind turbines up to 750 kW. The transition towards larger wind turbines of 1–1.5 MW might change the situation. The components industry is developing its product range to fit the large-scale turbines. This has required some investment in new production facilities.

A blade heating system for wind turbines operating under icing conditions was released as a commercial product in 1998. It has been developed mainly for the domestic market but also for export. The first delivery to Sweden was made in 1998.

11.3.2 Support Industries

Four Danish manufacturers have selling agents operating in Finland. Further, there are several small and one large consulting company working in the field of wind energy. They carry out a wide range of activities, such as feasibility studies, engineering, environmental analyses, and potential studies. They are also offering full turn-key delivery and O&M services, but, because of the slow development of the market, they have not yet been able to carry out these activities.

11.4 ECONOMICS

The Finnish electricity market was liberalized in 1995 and, since early 1997, small consumers are able to act in the market. Since September 1998, households can buy their power from any producer without hour-wise measurements. This means that power sales are separated from distribution and that anyone can buy power from anywhere and receive the power through the common grid. Every producer has, however, a balance responsibility.

Specific co-operatives and wind energy producers have started activities to use the free energy market and to sell wind energy to dedicated customers. Also the power companies and utilities have taken measures to have some wind power in their product-line, in order to satisfy their customers.

Thus there is no fixed price at which wind power is rewarded by the utilities. Rather, every producer has to find its own customers and find an agreement on the retail price. Several utilities offer their customers a “green power tariff” with an extra charge of FIM 0.02-0.04/kWh that is allocated directly to the wind energy producer. For example, the Society for Nature Protection Finland offers a “green energy certificate” to the production of renewable energy (including old hydro-power plants). The success of these tariffs has, however, so far been modest.

Average prices of electricity for industry is in the range of 0.31-0.38 FIM/kWh and for domestic consumers 0.33-0.60 FIM/kWh, depending on location and the time of day.

11.5 MARKET DEVELOPMENT

11.5.1 Market Stimulation Instruments

The Ministry of Trade and Industry (MTI) can subsidize installations by up to 45% of the investment. The percentage is decided upon on a project-by-project basis and handling time has been rather long, up to over half a year. Preference is given to projects that include some kind of technical innovation.

Beginning in 1997, the taxation was moved from energy production to energy consumption. Where the production tax was CO_2-related, the consumption tax is a general electricity tax that does not consider fuel or any environmental impact. However, wind energy and other small local energy production methods receive extra support of FIM 0.04/kWh, corresponding to the electricity tax for industrial consumers. For other small local energy production, the support is 0.02 FIM/kWh.

11.5.2 Institutional Factors

Regional Environmental Centres have authority regarding planning and environmental issues in the respective regions. Some of them have a strong negative attitude toward wind energy. Several prospective projects have been stopped, either by local or regional councils, due to the difficulty in getting planning permission.

In 1997, a working group of the Ministry of Environment published a draft report concerning how wind turbines should be considered in local and regional planning and which factors should be concerned in the handling of applications for planning permissions for wind turbines. The final report is expected soon and is directed towards local and regional planning authorities.

11.5.3 Impact of Wind Turbines on the Environment

The visual impact on the landscape is the most difficult planning problem related to wind energy and, after economics, this is the most significant obstacle to development. The reason is simply that the regions with the most wind are also very picturesque and environmentally valuable. In particular, the Finnish archipelago is significant in shaping our national identity. Further, many Finns have summer cottages in the countryside, especially in the archipelago and other coastal regions. At their summer cottages, people want to have a close relation to untouched nature. They do not want modern technology, like wind turbines, nearby.

11.6 GOVERNMENT-SPONSORED R, D&D PROGRAMS

11.6.1 Funding levels

The national research program, NEMO2 for Advanced Energy Systems and Technologies, came to its end in 1998. Therefore, there is no dedicated program in 1999 for wind energy R&D. Most of the

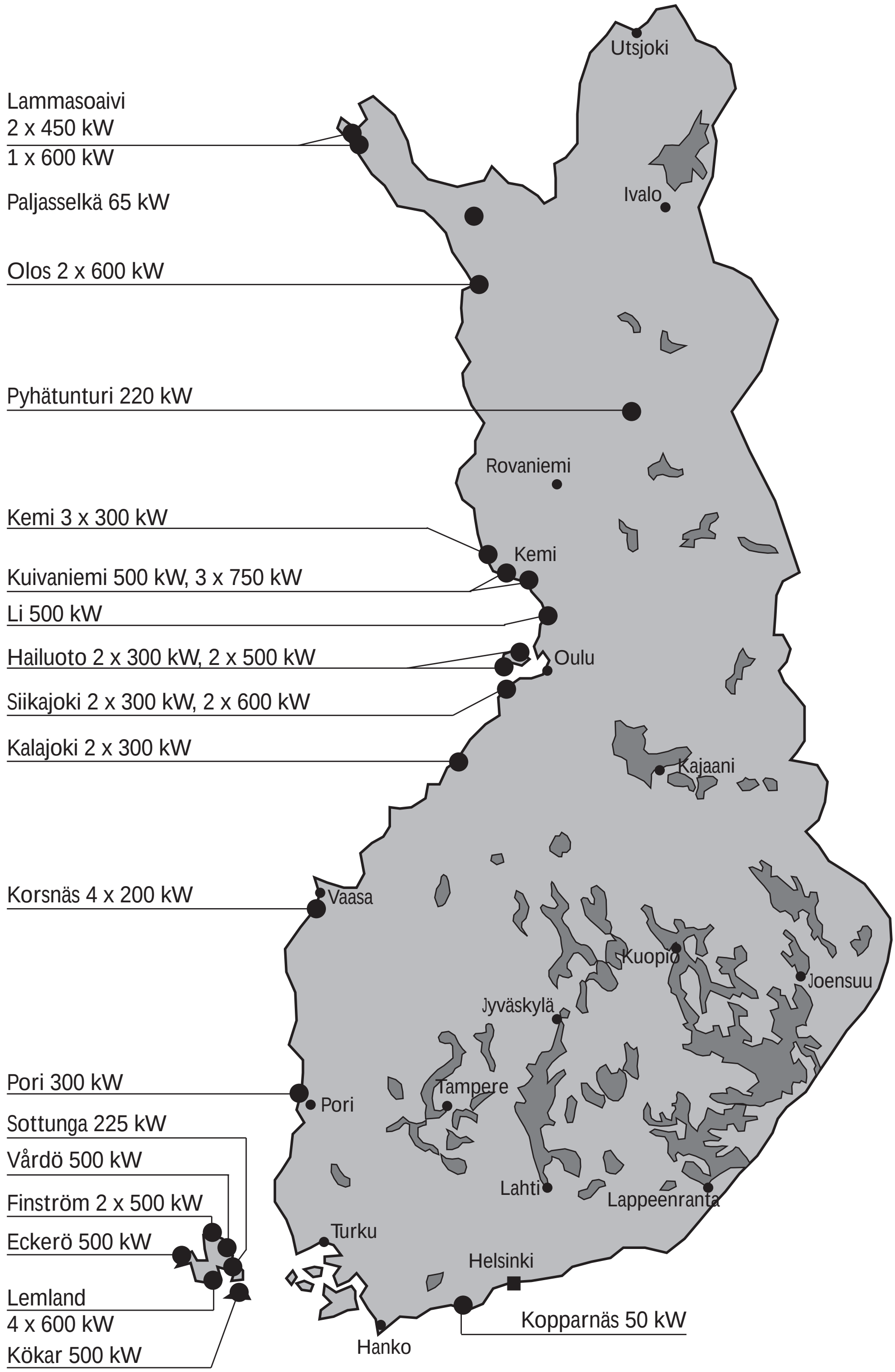

Figure 11.2 Location of Installed Wind Turbines in Finland

Figure 11.3 Pictured are two of the three 600-kW turbines Installed in October 1998 on an island about 700 m from the shore in Kuivanimei.

R&D related to wind energy has been carried out since 1989 within NEMO2 and its predecessor NEMO, funded by the Technical Development Centre Tekes. An assessment of the future needs and organization of wind energy R&D is underway. Wind energy research projects are still funded by Tekes, but decisions are made on a project-by-project basis. Wind energy projects have received public funding of about FIM 5 million per year.

11.6.2 Priorities

Priority is given to projects that have an industrial benefit, i.e. projects leading to results that can be rapidly utilized by the industry. An indicator of this is usually the amount of direct financing by the industry. Regarding wind energy, priority is given to projects that strengthen the position of the component industry and projects that increase the value added of material supplies.

11.6.3 Offshore Developments

R&D on offshore installations is focused on foundation technology. In addition to wave and wind loading, the foundation also has to take ice loads into account. The sea in offshore locations is covered with ice up to 100 days every year. To make matters worse, the whole ice field is moving and on the shorelines can build ice ridges that can reach up to 30 m height. Despite these difficulties, large-scale off-shore installations are possible with the foundation technology used in other applications, such as lighthouses.

R&D on offshore technology used to focus on the numerous small rocks and islands that were recognized as natural foundations for wind turbines. Due to environmental concern it has, however, been impossible to get planning permission for any such project.

11.6.4 International Collaboration

Most international R&D collaboration is carried out within the European Union's research programs. There is also active participation in the dissemination programs.

R&D projects funded by the EU programs can be co-funded up to 20% by TEKES if the projects fit in with the general targets for technical R&D, that are described above.

A working group for bilateral co-operation with Russia in the field of renewable energy was started in 1995. The main objectives are to maintain the research potential in Russian research institutes and to assist broader international co-operation.

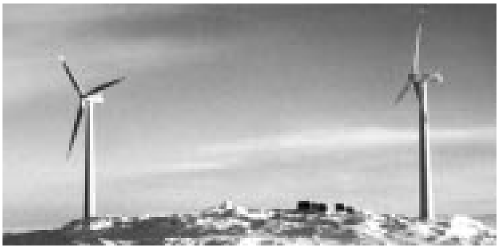

Figure 11.4 Two 600-kW turbines are installed in October 1998 on top of the Olostunturi Mountain in Lapland.

CHAPTER 12

12.1. GOVERNMENT PROGRAMS

12.1.1. Aims and Objectives

The actual program, the “4th Program for Energy Research and Technology”, has been in force since 1996 and has again been carried out by the Federal Ministry for Education, Science, Research and Technology (BMBF). The development of wind power is a part of this program. By December 1, 1998, the new government in Germany transferred the department for applied energy research of BMBF to the Ministry of Economics, forming the new Ministry of Economics and Technology (BMWi). The development of wind power (Research and Technologie, “250 MW Wind” –Program, ELDORADO) was included in this transfer.

The program follows consistently the goals of the former programs to conserve limited resources, to improve the security of the German energy supply, and to protect the environment and the climate. Two general objectives are emphasized.

1. Creation of the necessary prerequisites.
2. Contribution to the modernization of the national economy, to maintain the German technology position and to improve the exports.

Research and technology policy should set boundary conditions which allow the development of a sufficiently broad spectrum of technical options.

12.1.2 Strategy

The strategy of the R&D funding of the 4th Program follows three aims.

1. Improvement of the performance and reliability of existing techniques,
2. Development and demonstration of technological concepts for the future,
3. Support of basic research for 1. and 2. above.

In the short and medium term, an important contribution to decrease energy consumption and to reduce CO_2 emissions is expected from the improvement of thermal power stations and a further use of rational energy.

In the medium or long term, renewable energies are expected to contribute significantly to the German energy supply and to reduce CO_2 emissions. Technically rather advanced, but not in all cases economically competitive, is the utilization of heat (solar thermal, heat pumps, biomass) and electricity (wind power, waste contribution, biomass, photovoltaic).

The full range of strategy measures covers various technologies. For this report, the item Renewable Energies and Rational Use is of special interest.

R&D of Renewable Energies are supported in photovoltaic energy, wind power (including the “250 MW-Wind”–Program), biomass, geothermal energy and other renewables as well as in application systems for southern climatic conditions.

Supported R&D fields of Rational Energy Use / Saving of Fossil Energy for Consumers are solar thermal power and heating of buildings, heat storage, and energy-saving industrial processes.

Including the corresponding R&D in large German research facilities, both areas in 1998 disposed of a total budget of about 260 million DEM (Renewables have about 200 million DEM).

12.1.3 Targets

The “4th Program for Energy Research and Energy Technologies” is related to the political target of the German government to reduce CO_2 emissions by 25% by the

Table 12.1 Development of Wind Power in Germany: “250 MW Wind” and Total by October 31, 1998

DATE	NUMBER OF WECs		RATED POWER (MW)		WIND ELECTRICITY PRODUCTION (10^9kWh)	
	250 MW WIND	TOTAL	250 MW WIND	TOTAL	250 MW WIND	TOTAL
12/31/1989	15.0	256.0	1.4	20.0	0.0003	—
12/31/1990	187.0	506.0	30.8	60.0	0.0160	0.58
12/31/1991	439.0	806.0	72.2	111.0	0.0890	0.13
12/31/1992	738.0	1211.0	121.3	183.0	0.2010	0.28
12/31/1993	1058.0	1797.0	183.9	334.0	0.3020	0.50
12/31/1994	1317.0	2617.0	255.5	643.0	0.4620	1.00
12/31/1995	1466.0	3528.0	311.0	1120.0	0.5430	1.50
12/31/1996	1552.1	4326.0	335.0	1546.0	0.5230	2.00
12/311997	1511.0	5193.0	343.8	2082.0	0.5800	3.00–3.30
12/311998	1510.0	6205.0	345.0	2874.0	—	—

year 2005 from 1990 levels. Sustained implementation of the program will contribute to reaching this target together with measures taken in other fields, such as traffic. German industry will contribute to the government obligation, as declared on March 1996, by reducing its specific CO_2 emissions by 20% by the year 2005 compared to 1990 levels.

Governmental targets for wind energy in Germany are not specified. In governmental publications, yearly wind electricity production of up to several per cent of total electricity production is considered to be possible. Within the “250 MW Wind” Program a total rated power of about 345 MW will be reached (250 MW refers to the WECS power at 10 m/s wind speed), corresponding to a yearly electricity production of all turbines (including the early, smaller WECS) of roughly 1800 h x 390 MW ± 10% = 0.7 x 10^9 kWh ± 10%, or almost 0.2% of the total electricity actually produced.

Two German Federal States published specific targets. Lower Saxony: 1,000 MW by the year 2000 (status by December 1998: 812 MW) and Schleswig-Holstein: actual produced 1,200 MW by the year 2010 (Status by December 1998: 746 MW). The corresponding actual share of the electricity consumption in Lower Saxony is 3.8% and in Schleswig-Holstein 13.4%.

12.2. COMMERCIAL IMPLEMENTATION OF WIND POWER

12.2.1 Installed Wind Capacity

By December 31, 1998, the number of installed wind turbines was 6,205, with a total rated power of 2,874 MW. Some 1,103 turbines with a total of 841 MW were installed in 1998.

The total number of turbines in operation by December 31, 1998 within the “250 MW Wind” Program was 1,510 (24% of all WECS), corresponding to a total of 345 MW (12% of the total capacity). The development of wind power in Germany is shown in Table 12.1. The distribution of wind

Table 12.2 Distribution of Wind Power for the German Federal States 1998

FEDERAL STATE	RATED POWER TOTAL	NUMBER OF WECS TOTAL
Schleswig-Holstein	746.0	1667
Niedersachsen	812.0	1715
Nordrhein-Westfalen	325.0	856
Mecklenberg-Vorpommern	216.0	425
Hessen	155.0	290
Brandenburg	148.0	300
Sachsen	136.0	250
Sachsen-Anhalt	93.0	186
Rheinland-Pfalz	81.0	203
Thüringen	71.0	122
Bayern	31.0	67
Hamburg	18.0	39
Baden-Württemberg	22.0	52
Bremen	8.0	20
Saarland	6.0	13
Berlin	1.0	3

power for the 16 German states is given in Table 12.2.

The total rated power of wind turbines by the end of 1998 in the three coastal Federal States Niedersachsen (Lower Saxony), Schleswig-Holstein, and Mecklenburg-Vorpommern was 1,794 MW (62% of the total installed power) corresponding to 3,807 WECS.

12.2.2 Comparison with Conventional Public Electricity Consumption

The total public electricity consumption in Germany for 1998 was 436 x10^9 kWh. According to the data given in the Table 12.1, it follows that during 1998 wind power contributed 0.68% to German public electricity consumption (1996: 0.5%). The contribution of all renewables, mostly hydro-power, is around 5%. For 1998 the wind power contribution to public electricity consumption will increase again and should surpass 1%.

12.2.3 Numbers/Type, Make of Turbines/Ownership

The statistics of different WECS types are available for WECS within the “250 MW Wind” Program, see Table 12.1. The table represents the situation from the beginning of the program in about 1990 until today. In 1990, many smaller WECS—no longer on the market—came into operation. Thanks to the “250 MW Wind”-Program, the statistics of ownership are known.

Table 12.3 Ownership of WECs of "250-MW" Wind Program by January 1999

OWNERSHIP	PROJECTS	WECS	RATED POWER (MW)	RATED POWER (kW)
Private individuals	594	678	121.6	179
Farmers	250	257	35.7	139
Trade and industry	237	452	165.3	366
Communities	51	57	7.41	30
Electricity companies	31	66	20.1	304

See Table 12.3. Private individuals and trade and industry (including the so-called power investors) erected by far the largest part of the total rated power, but trade and industry is leading with the average WECS size. For the number of turbines installed in 1998 and in total we refer to the previous section and Table 12.4.

These numbers again reflect the development of wind power in Germany since 1989/90. Farmers and private individuals bought the smaller WECS available at that time, whereas today trade and industry, mostly new firms, invest in projects with WECS of the commercial 500- to 600-kW and MW class of European manufacturers.

12.2.4 Performance and Operational Experience

The average technical availability for 1997 was 99%. That means an average standstill time of about 85 hours per year per unit. The performance of wind turbines in Germany is recorded within the "250 MW Wind" Program. For this purpose, ISET carries out a Scientific Measurement and

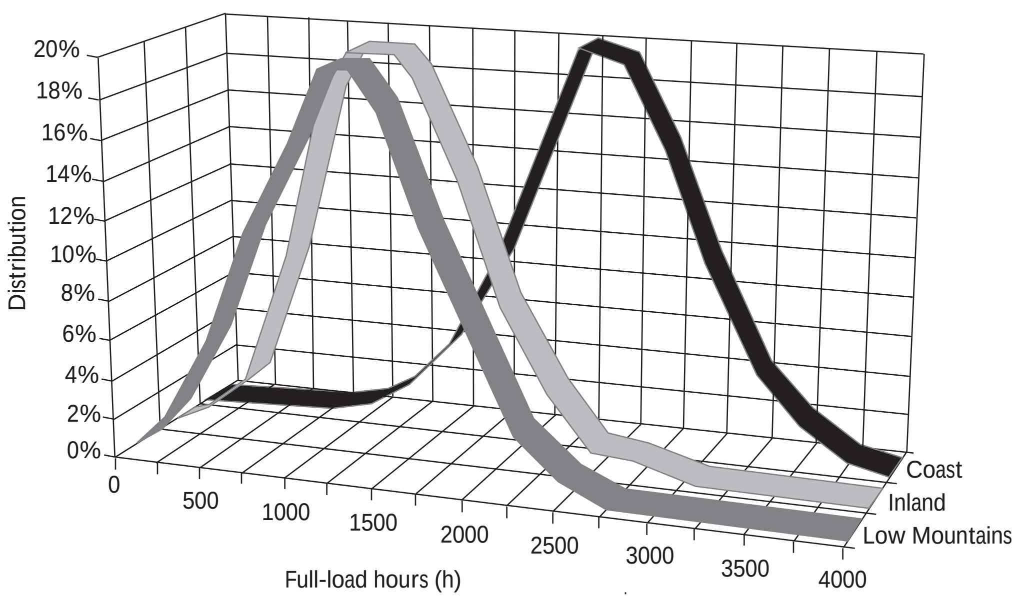

Figure 12.1 WMEP: Distribution of Full Load-Hours in Germany

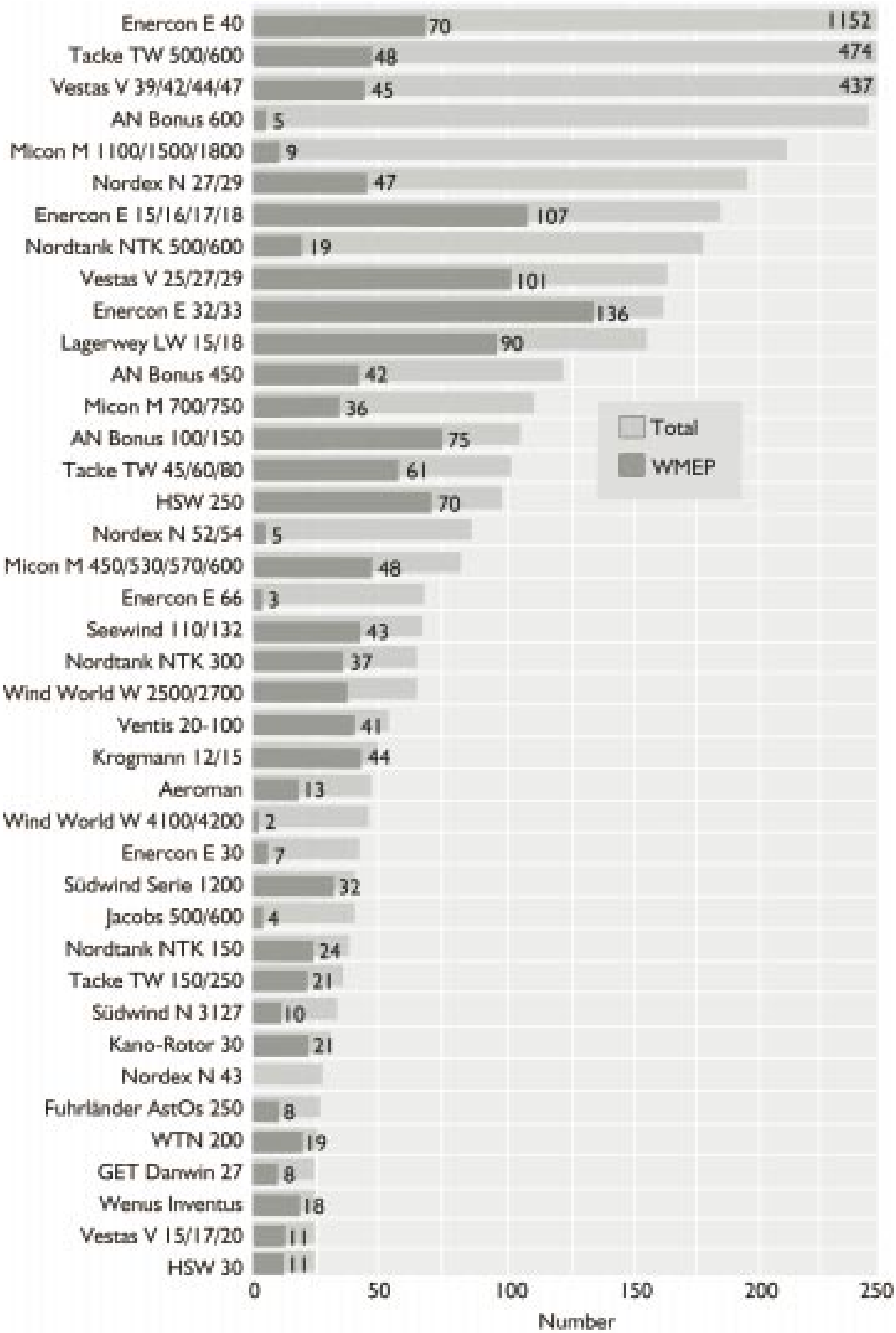

Figure 12.2 WEC Types by December 31, 1998

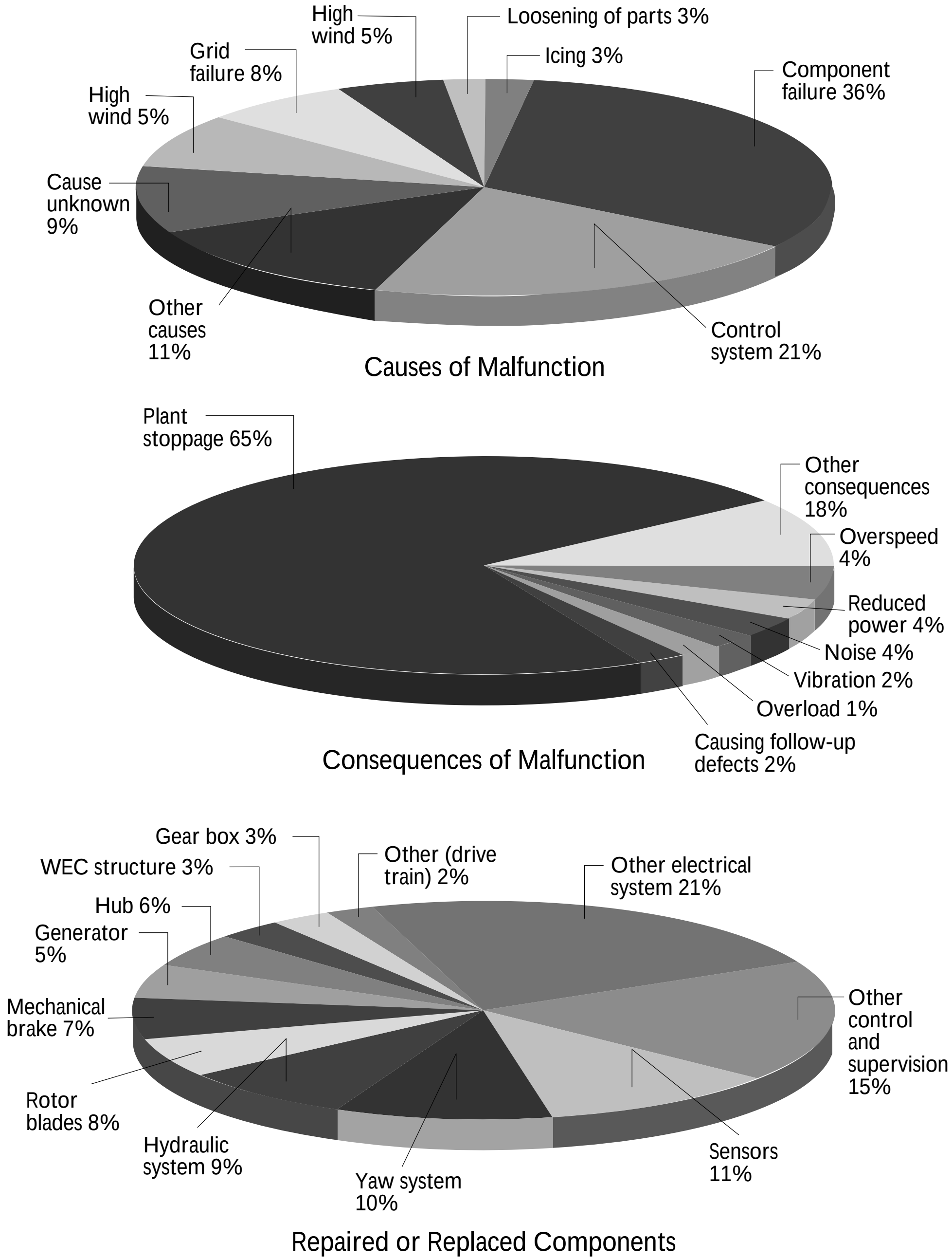

Figure 12.3 WMEP Failure Statistics for 1997 (1511 WECs)

Evaluation Program, WMEP, on behalf of BMBF.

Figure 12.3 shows examples of failure statistics and statistics of repaired and exchanged parts. More than 50% of the causes of failure are identified with component failure and control system of the WECS, a quarter of the causes are identified with external influences (high wind, grid failure, lightning, and icing).

12.3 MANUFACTURING INDUSTRY

12.3.1 Market Shares

Table 12.4 shows the shares of the suppliers on the German market in 1998. This indicated that the MW-size turbines are increasingly popular. Table 12.5 shows a typical snapshot of wind power development in Germany. The table shows that, in October 1998, no small WEC was erected and that wind power development continues to grow in inland Federal States.

12.3.2 New Products and Technical Developments

The excellent availability of the WECS installations in Germany, as well as the average installed power of 762 kW/turbine for new turbines in 1998, indicate a rapid technical development of wind power. This is not limited to German manufacturers, as shown in Table 12.4 Market Shares. The share of new installed WECS with a rotor diameter of more than 48 m was about 40% in this period.

12.3.3 Business Developments

The number of direct and indirect employees in the German wind power industry is at present around 10,000. The total commerce connected with WECS in Germany in 1997 amounted to 1.3 billion DEM. In addition, service teams had to be set up. On the average, one service person is required for each installed capacity of 20 MW. These jobs are needed for the lifetime of the turbines. Good service teams are most important to maintain the excellent availabilities (averaging 99%) obtained in Germany. Special data for 1998 are not yet published, but the estimated total volume of capital investment in the first six months of 1998 adds up to about 675 million DEM.

12.4. MARKET DEVELOPMENT

The rated power of installed turbines has increased significantly over the years. In 1989 and 1990, the market offered WECS

Table 12.4 Market Shares 1998 in Germany

MANUFACTURER	RATED POWER %	WECS %
ENERCON	33.1	35.5
NORDEX	15.2	13.5
VESTAS	12.3	12.7
ANWINDENERGIE	9.4	9.6
TACKE WIND	9.4	8.1
NEG MICON	8.1	6.1
DEWIND	2.8	3.6
SUEWIND	2.4	3.0
OTHERS	7.3	7.9
TOTAL	100.0	100.0

Table 12. 5 New Installations in October 1998 in Germany

NUMBER	WEC MODEL (KW)	RATED POWER (M)	HUB HEIGHT (M)	ROTOR DIAMETER	FEDERAL STATE
2	AN Bonus 1 MW/54	1000	70	54.0	Sachsen-Anhalt
1	DeWind 48	600	60	48.0	Rheinland-Pfalz
1	DeWind 48	600	60	48.0	Nordrhein-Westfalen
1	Enercon E 40	500	51	40.3	Sachsen
2	Enercon E 40	500	65	40.3	Brandenberg
4	Enercon E 40	500	65	40.3	Nordrhein-Westfalen
3	Enercon E 40	500	65	40.3	Rheinland-Pfalz
1	Enercon E 40	500	65	40.3	Hessen
2	Enercon E 40	500	65	40.3	Rheinland-Pfalz
1	Enercon E 40	500	65	40.3	Bayern
1	Enercon E 66	1500	70	66.0	Sachsen-Anhalt
3	Enercon E 66	1500	70	66.0	Mecklenburg-Vorpommern
4	Enercon E 66	1500	70	66.0	Niedersachsen
1	NEG Micon NM 600-150/48	600	60	48.0	Brandenburg
1	NEG Micon NM 600-150/48	600	60	48.0	Baden-Württemberg
1	Nordex N 27/150	150	50	27.0	Schleswig-Holstein
1	Nordex N 43/600	600	60	43.0	Baden-Württemberg
4	NordexN 54/100	1000	60	54.0	Niedersachsen
2	Tacke TW 1.5	1500	80	65.0	Niedersachsen
1	Tacke TW 600e	600	60	46.0	Nordrhein-Westfalen
1	Vestas V 47/660	660	65	47.0	Nordrhein-Westfalen
4	Vestas V 66/1.65	1650	67	66.0	Schleswig-Holstein

with a maximum power of 250 kW. These were soon followed by turbines producing 300 kW. Nevertheless, the majority of plants still had a rated nominal power of 100 kW or even less. The typical operator was assumed to be a farmer who produced electricity for the needs of his own farm and fed the surplus electricity into the grid. This situation has rapidly changed owing to the technical and economical development of WECS.

Most of the WECS erected in 1997 and 1998 have a rated power of 500 kW and more. In 1997 the introduction of the 1,500-kW class started very successfully.

Market constraints, especially in the German coastal areas, include complaints that wind turbine installations are destroying the landscape and disturbing wildlife and birds. Neighbors of WECS complain of noise and shadow effects. Germany has a high population density and is short of good wind sites, where different users are often competing. Owing to the necessity of noise emission reduction, a distance of about at least

500 m to the next resident is recommended for large-scale WECS. Although the land around a WECS can still be used as farmland, there are a lot of complaints. Over the past few years, it has become more and more difficult to get a construction permit for WECS.

12.5. ECONOMICS

The rapid market development the late eighties to the nineties was driven by the favorable financing conditions in the period. The “250 MW Wind” Program, at that time the “100 MW-Wind“ Program, of BMBF led the way.

The “Electricity Feed Law“ (EFL) became effective by January 1, 1991. Since then, the utilities have been obliged to pay the same 90% of the average tariffs per kWh that private consumers have to pay, with taxes of 15% excluded. In 1997 this amounts to 0.1715 DEM/kWh and 0.1679 DEM/kWh in 1998. EFL and “250 MW Wind“ Program are cumulative.

In April 1998, a modification of the EFL within the reformation the energy law came into force. The changes in the EFL do not affect this refunding, but specify the financial charges of the different utilities of the German grid and set a date for reconsideration of these specifications by the Bundestag (1999).

The discussion of possible changes of the EFL 1997 caused considerable concern in the German Wind Power Market. But the final result for 1997, an additional 534 MW of wind power in Germany, was even better than in 1995. In 1998, there was an increase of the newly installed capacity of 57% over 1997.

In addition to the reimbursement according to the EFL, a wind turbine operator might get soft loans. The Deutsche Ausgleichsbank offers soft loans for WECS, while some other states, especially in the German inland, still conduct programs with direct funding (Nordrhein-Westfalia).

Over the last eight years, a market for wind turbines has been established in Germany which does not depend on direct funding. This market depends on the conditions for reimbursement regulated in the EFL; the development of turn-key prices of WECS; and the interest rate for loans and mortgages. High interest rates for mortgages with a pay back time of 10 years was reached at about 10% by April 1991. This was followed by a fluctuating decrease to less than 5% in 1998. Assuming a pay back time or a depreciation time of 10 years, it can be calculated by established methods that a decrease of three percent in interest corresponds to a price decrease of 25%.

The revenue from WECS is mainly determined by the electricity production, which can be expressed by hours of operation per year at nominal power. Under German meteorological and financial conditions, it is more or less generally accepted that for a WECS erected in 1998 the revenue will be higher than the expenses when 2,200 hours at nominal power are obtained. At good sites close to the German or to the Baltic Sea, where the mean wind velocity at a height of 10 m is between 5.5 and 6 m/s, the majority of WECS have lower production costs than revenue per kWh according to the EFL. The inland situation, where typical wind velocities of 4 m/s dominate, might be different. The actual distribution of full load hours for different site categories for WECS within the “250 MW Wind” Program is shown in Figure 12.2. The broad distribution of full load hours is remarkably broad for the three site categories. This indicates that, besides the general wind regime, other factors like the size and type of the turbine and the local wind conditions may influence the full load hours considerably.

Financing of WECS is often managed with low equity. Even on inland sites, the projects are sometimes financed completely by loans. Here, the revenue from the WECS is needed in the first ten years to pay for the capital costs, the insurance, and O&M. But the investor may nevertheless make some profit. A depreciation time for WECS of ten years was possible until mid-1997. From July 1st, the depreciation time is 12 years. With a linear depreciation, investors can reduce their taxable income by about ten percent of the turn-key costs per year. This corresponds to approximately DEM 100,000 per annum. With an assumed tax rate of thirty percent, the taxes to be paid by the investor will be reduced by about DEM 30,000 per annum. Under the circumstances considered, almost no corporate taxes will have to be paid in the first ten years. Reducing the taxable income is one of the driving forces of the German WECS market. On average, every investor is reducing annual taxes considerably.

12.6. GOVERNMENT-SPONSORED PROGRAMS

12.6.1 Funding 1997

The BMBF 1998 funding levels of wind power were (1997 in brackets) the following:

R &D	DEM	4.5 (5.5) million
“250 MW Wind”	DEM	37.2 (35.3) million
ELDORADO	DEM	1.3 (6.3) million
Total	DEM	43.0 (47.1) million

In addition, the Federal Ministry of Economics supports renewable energies within special guidelines for the period 1995-1998. The guidelines include the investment grants for wind turbines of rated power from 450 kW to 2 MW at sites with average wind speeds up to 4.5 m / s at 10 m height above ground. About 10 projects per year with a total of around DEM 1 million are being realized.

12.6.2 R&D / WMEP

Recent R&D projects by BMBF are shown in Table 12.6. The projects include the engineering of a 4-MW, 110-m turbine, to be erected in about two years. The Scientific Measurement and Evaluation Program, Phase III (WMEP) involves a DEM 13,683 million contract for the period of July 1996 to June 2000.

In autumn 1998, experts reviewed the future of R&D for wind energy technology on behalf of BMBF. Despite the fact that this technology has made a rapid technical development in the last 10 years and that markets for wind power have opened worldwide, there is still much work left to be done in many technical areas to fulfill the potential of wind power as a key contributor among renewables to the world-wide energy supply.

12.6.3 “250-MW Wind“ Program

The goal of the “250 MW Wind” Program is to carry out a broad test of the application of wind energy on an industrial scale, which extends over several years. As an incentive for their participation in the “250 MW Wind” Program, operators of the wind turbine / wind farm receive grants for the successful operation of their installations.

The current subsidy for operators in the “250 MW Wind” Program is either DEM 0.06 or DEM 0.08 per kWh, depending on whether the energy is fed into the grid or is being used by the owner of the WECS. The latter applies for instance to a farm, a factory or a private household, and also to a utility as a WECS owner. The grants are limited to a maximum of 25% of the total investment costs. In certain cases (private individuals and farmers) a subsidy of the investment, limited to DEM 90,000, is possible.

The interest in support of the “250 MW Wind” Program was high. Until the

Table 12.6 Energy R&D Projects, 1997 and the WMEP Phase III

SUBJECT	PERIOD	COSTS (DEM)	BMBF (%)
Wind powered desalination plant, Rügen	06/93-05/97	3,891.50	70.00
Processing of wind measurement data up to 150 m for planned archive of wind data	04/92-01/98	607.00	100.00
Special wind data and programs for complex terrain	07/93-06/97	1,641.90	100.00
Phase III of 250MW wind measurement and evaluation program WMEP	07/96-06/97	13,683.50	100.00
Early recognition of turbine failure	01/94-12/97	1,431.80	50.00
Fatigue loads WECS	07/95-06/97	443.60	50.00
MW WECS inland	06/95-09/99	4,893.60	20.43
Control LS WECS	07/95-06/99	1,192.60	40.00
Active stall rotor blade	08/96-07/98	2,505.98	50.00
Lightning protection WECS	10/96-09/99	600.00	50.00
Development of a 4MW WECS	08/98-2000	10,000.00	35.00

closing date for proposals (December 31, 1995), more than 6,000 proposals were registered. This corresponded to a total rated power of more than 3,500 MW. During the development of the program, a total of 1,223 proposals were approved, corresponding to 1,573 WECS and 384.5 MW. The last approvals were for some projects with the new MW-size turbines erected in 1998. The program will end around the year 2008 after 10 years of WMEP participation of the MW-size turbines. It is expected that the total support will exceed DEM 350 million. The costs of the measuring program are not included in this sum and could reach an additional DEM 60-70 million for the period 1990 to around 2007.

12.6.4 “ELDORADO Wind“ Program

BMBF’s interest also includes the application of wind energy in overseas countries. According to a study by the World Bank, almost 50% of the inhabitants in developing and threshold countries do not have access to central energy supplies (electricity, oil, gas, and so forth). They could be assisted by decentralized concepts, and renewable energies are considered to be an option for decentralized energy supplies. Therefore, BMBF launched the “ELDORADO Wind” Program in 1991, which is now being jointly carried out with 10 partner countries. The aim of BMBF is to encourage a large number of users in southern climatic zones to construct and operate WECS in co-operation with German partners. By October 31, 1998, 29 projects were approved by BMBF, most of them with installations in operation. The total rated power is 30 MW (see Table 12.7).

CHAPTER 13

13.1 GOVERNMENT PROGRAMS

There has been no revision of the National Program of Greece during 1998. Greece is one of the European countries possessing high wind energy potential. It is among the aims of the government to replace expensive imported fuel, currently used for electricity production in a large part of the Greek territory, by exploiting the country's wind potential. Government support for wind energy exploitation is part of a larger new policy, concerning renewable energy sources. The major strategic goals of the national policy for the development of the renewable energy sources are the following:

1. Increase of the efficiency of the energy system.
2. Protect the environment by decreasing the emission of atmospheric pollutants.
3. Improvement of the safety of the energy system by diversifying energy supplies.
4. Reduce CO_2 emissions by 2000 to the levels of 1990.
5. Decentralize energy production.
6. Actively involve Greek industry in creating new jobs.
7. Develop new technology.

In 1995, a target of 350 MW of installed wind energy capacity by the year 2005 was announced by the Ministry for Development (MD). A new legal framework gave significant stimulus to the development of wind energy in Greece. The new Law 2244/94, dealing with and regulating electricity production from renewable energies, was followed by a ministerial decree detailing its implementation. The main features of the new framework regarding wind energy are the opening of the market to the private sector and the precise definition of tariffs for energy produced. In addition, the Public Power Corporation of Greece (PPC) is obliged to buy the wind-produced electricity through contracts having a 10-year duration, with the possibility of a 10-year extension.

There are two national programs currently supporting wind energy projects. First, wind projects may be subsidized up to 45% of the project cost and get up to 40% reduced interest rate soft loan (up to 20% of the project cost). This is implemented within a continuous program according to the "Law for the Economic Development" 2601/98 of the Ministry for National Economy launched in 1998.

Second, the so-called Operational Program for Energy (OPE)-Renewables within the Community Support Framework, for the years 1994–1999, is implemented by the Ministry for Development. The total budget for renewables, including private contributions, is 50 billion drachmae. Financial support for wind energy is 40%, considering the maximum subsidized project cost 350,000 drachmae/kW.

During 1997, there were two calls for proposals in the framework of the OPE. After the first call, five proposals for wind projects were accepted, with a total budget of 8.5 billion drachmae, corresponding to 22.8 MW installed capacity. The results of the second call were announced during 1998. Fifteen projects of 106.4 MW total installed capacity were accepted for funding having a total investment budget of 37.8 billion drachmae.

13.2 COMMERCIAL IMPLEMENTATION OF WIND ENERGY

The first large-scale private wind farm was put in operation this year on the island of Crete. A 10.2-MW wind farm, comprising seventeen 600-kW Bonus wind turbines was inaugurated in May 1998, and it is now fully operational. In total, 19 WECS having an installed capacity of 11.45 MW were connected to the electricity supply network in 1998, bringing the total installed wind energy capacity to 39.6 MW (177 machines).

The development of wind energy within the last nine years is shown in Figure 13.1, where the total installed capacity per year is depicted.

The energy produced from wind turbines during 1998 is approximately 71 GWh, while the energy produced in 1997, 1996, and 1995 was 38 GWh, 37.2 GWh, and 33.4 GWh, respectively. Figure 13.2 shows the electricity produced from wind turbines for the last eight years and the corresponding capacity factors.

In 1998, major repairs were undertaken at the two biggest wind farms of PPC. These farms, totaling 5.1 MW each (17 x 300 kW Windmaster), have been out of operation since the beginning of 1994 due to serious damage to their rotor blades. The wind farm on Crete has been fully operational since May 1998, and the second wind farm is close to having repairs completed.

13.3 MANUFACTURING INDUSTRY

Except for a couple of small wind turbine manufacturers (typical range 1.0–5.0 kW), there is no wind turbine manufacturing industry in Greece. However, all the tubular towers for imported machines of PPC were constructed in Greece by two private companies, following the original drawings. The steel industry is quite developed in the country and can easily support wind turbine manufacturing. In the past, the Hellenic Aerospace Industry (HAI) was involved with the construction of wind turbines for PPC. But its activities were limited to a program of 50 machines based on imported Danish know-how.

A certificate from a certifying authority is required to operate a wind turbine in Greece with a rating of more than 20 kW, unless it is owned by PPC. The Center for Renewable Energy Sources (CRES) is, by law, the certifying authority for wind turbines in Greece. However, CRES accepts approval certificates issued by authorized

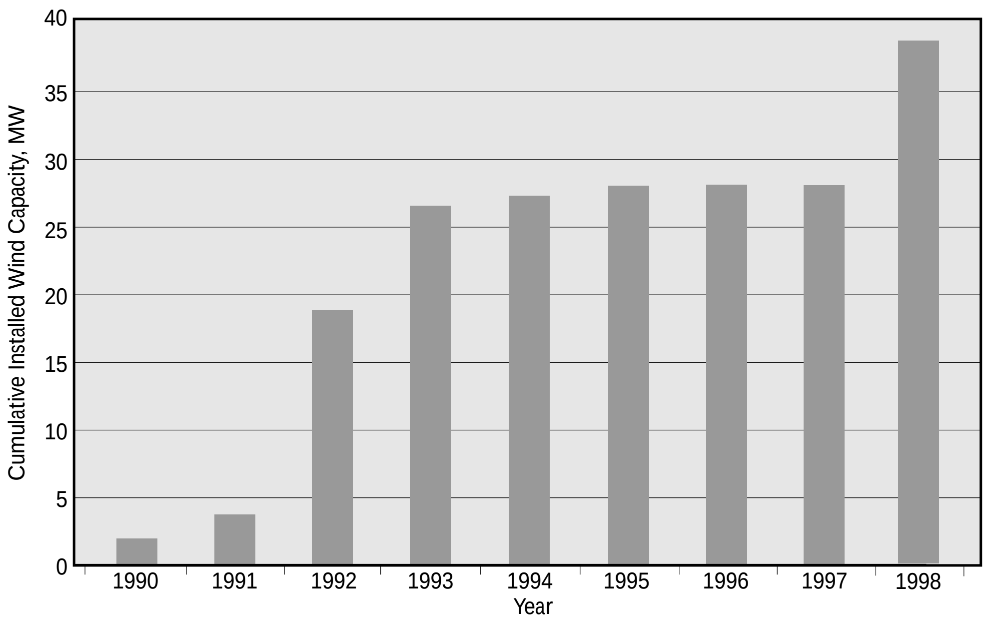

Figure 13.1 Cumulative Installed Wind Capacity in MW

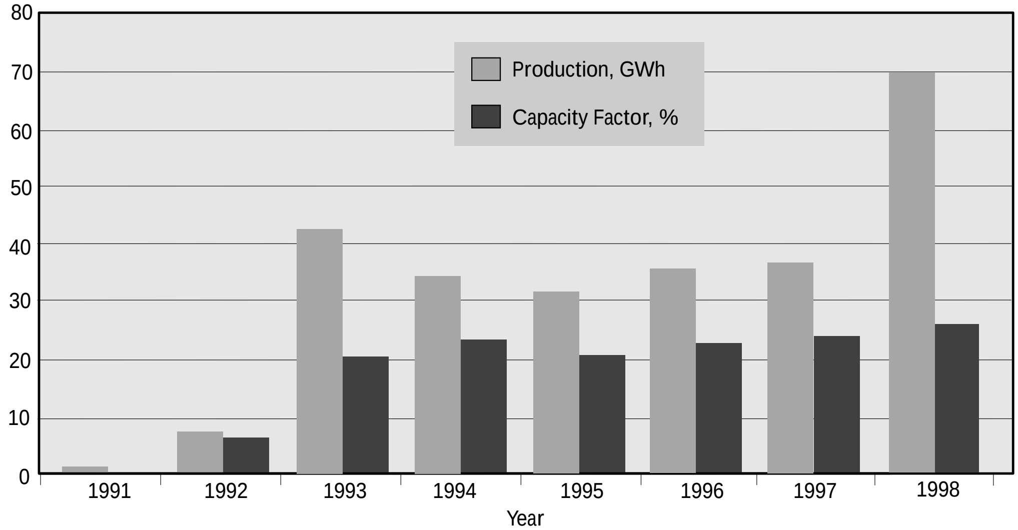

Figure 13.2 Wind Power Annual Output and Capacity Factor

institutions, while it is working on certification procedures and standards to be followed nation-wide, taking into account the individual climate characteristics of Greece.

13.4 ECONOMICS

The system of power generation in Greece is divided into two categories: the so-called interconnected system of the mainland and the autonomous power plants of the islands. PPC is the only utility responsible for production, distribution, and exploitation of electricity. Despite the different production costs in the two systems, a single price for electricity is charged all over the country, depending on the identity of the consumer and the voltage class. The following tariffs for the three voltages have been valid since July 15, 1998.

1. Low Voltage 26.60 Drs/kWh,
2. Medium Voltage 21.51 Drs/kWh and 994 Drs/kW (peak power value),
3. High Voltage 14.05/ 7.22/9.74 Drs/kWh, peak/min load/rest hours respectively 2191 Drs/kW (peak power value),

The prices paid by PPC for renewable energies are based on the actual selling price. For the autonomous island grids, the prices are set at 90% of the low voltage tariff, i.e. 23.94 Drs/kWh. For the interconnected grid, the tariffs have two components: energy and power (capacity credit). The energy component is set at 90% of the medium or high voltage tariffs, depending on the type of grid connection of the wind power plant. The power component is set at 50% of the respective PPC power charge.

1. Medium voltage 19.359 Drs/kWh and 497.0 drs/kW x P (P: the maximum measured power production over the billing period),
2. High voltage 12.645/6.498/8.766 Drs/kWh, peak/min load/rest hours respectively 1128.5 Drs/kW x P (P: the maximum measured power production between two successive measurements in the peak hour zone).

The total cost of wind power projects depends on the type of wind turbine, its size, and its accessibility. It varies between 330,000–400,000 Drs/kW. The generated wind power cost could be assumed to be between 9.0 and 16.0 Drs/kWh, depending on the site and project cost.

The typical interest rate for financing any project without subsidies is about 14%. However, many investments including wind projects may profit by reduced soft loans according to the so called “Law for the Economic Development” 2601/98.

13.5 MARKET DEVELOPMENT

Low selling prices in conjunction with the restriction of power generation from the private sector (with the exception of auto production) strongly affected wind energy development, although the first wind turbines have been operating since 1984. As a result, wind energy was limited to the activities of PPC and of some public organizations.

As soon as the new Law 2244/94 was issued in early 1995, the private sector showed a great interest in developing wind power projects. According to the law, anyone can develop power plants up to 50 MW from renewable energy and sell electricity to PPC, marking the end of the monopoly of PPC on power generation from wind energy. Other features affecting the development are more simplified procedures (less bureaucracy) and attractive buy-back prices. Until now, applications for a total of 1,500 MW have been submitted to the Ministry of Development from which approximately 169 MW have completed the licensing procedure and been issued an installation license. Wind farms of approximately 50 MW capacity are under construction.

Due to the landscape characteristics of Greece, almost all wind power plants are sited in remote areas, thus minimizing complaints of visual and noise problems. In addition, no bird kills have been reported.

Although strong opposition defeated a projected wind farm on Lesvos Island due to archaeological interest in the area, there has been no other significant opposition against wind energy to date. The public attitude is rather positive in general; however, special attention should be given when planning projects on small tourist islands with strictly traditional architecture.

13.6 GOVERNMENT-SPONSORED R, D & D PROGRAMS

The Ministry of Development promotes all R, D&D activities in the country. Government sponsored R, D&D activities include applied and basic R&D as well as demonstration projects.

Key areas of R&D in the field of wind energy in the country are the following:

- wind assessment and integration;
- standards and certification;
- development of wind turbines;
- aerodynamics, structural loads, blade testing,
- noise, power quality,
- wind-powered desalination and,
- integration in autonomous power systems. There is no activity in Greece concerning MW-size wind turbines or offshore deployment.

13.6.1 Research and Development

A project for the development of a 450-kW wind turbine was initiated within the framework of the EPET-II National Program in 1995. The project is aimed at both the development of a 450-kW variable-speed, stall-regulated wind turbine and the development of blade manufacturing technology. The prototype is expected to be installed at the test site for extensive measurements in 1999.

CRES is the national organization for the promotion of renewable energy in Greece and, by law, the certifying authority for wind turbines. CRES is mainly involved in applied R&D and is active in the field of aerodynamics, structural loads, noise, power quality, variable speed, wind-desalination, standards and certification, wind assessment, and integration.

The development of a national certification system for wind turbines is considered a crucial parameter for the successful implementation of new strategic plans for extensive use of wind energy in the country. CRES' Wind Energy Department is continuing the development of the National Certification System, as well as participating in the standardization work carried out by the Hellenic Organization for Standardization (ELOT) in the framework of European and International organizations, regarding wind energy matters. In 1998 Greece has been actively involved in the activities of IEC TC-88, CLC/BTTF83-2, and its wind generators.

The CRES blade testing facility is going to be used as an integral part of the certification system underway. The facility is fully operational and several blade tests have already been conducted. The blade testing facility, which is one of the most advanced testing facilities in the world, can be used for static, dynamic or fatigue testing of blades up to 25-m long.

The CRES Wind-Diesel Hybrid Laboratory System, which simulates the small autonomous grid operation common in the islands of the Aegean Sea, has been fully operational and several tests have been made. The system can be effectively used in optimizing the integration of renewable energies in such small applications.

A number of research projects that were running or initiated at CRES during 1998, were co-funded by DGXII and GSRT (the Greek Secretariat for Research and Technology). Their goals included the following.

1. Characterizing the main features of complex or mountainous sites, because most of the favorable for wind energy development sites are of such topography); and identifying the crucial parameters affecting both the power performance and the loading of different types of wind turbines operating in such environments. In that direction, new techniques are under development for power-curve measurement of wind turbines operating in complex terrain,
2. Developing new techniques for power quality measurement and assessment,
3. Contributing know-how to wind turbine standardization procedures,
4. Developing blade testing techniques within the in-house experimental facility,
5. Understanding generic aerodynamic performance of wind turbine blades through CFD (Computational Fluid Dynamics) techniques,
6. Developing cost-effective micro-siting techniques for complex terrain topographies,
7. Developing GIS (Geographic Information System) techniques for optimum wind-energy planning on a local level,

Basic R&D on wind energy is mainly performed at the country's technical universities. The Fluids Section of the Mechanical Engineering Department of the National Technical University of Athens (NTUA) is active in the field of wind modeling, rotor aerodynamics, load calculation, fatigue analysis noise and wind farm design. In 1998, the R&D activities concerned mainly theoretical work related to numerical simulations. More specifically this work included the following.

1. A complete software for assessment of noise in wind parks was developed. The software includes: a siting module for the mean wind flow, a wind park

module which introduces the wake effects, a machine model which calculates the noise spectrum of the machines and a noise propagation module,

2. A new viscous-inviscid interaction model has been completed for airfoils. The model predicts lift and drag with state-of-art accuracy even beyond maximum lift. Its extension to unsteady light stall situations has been also concluded,

3. The development of a Navier Stokes flow solver for rotating blades has been concluded based on a multi-block architecture. Testing is foreseen for next year,

4. An aeroelastic code of the complete turbine has been concluded and successfully tested over several turbines. A shareware version is available upon request.

The Applied Mechanics Section of the Mechanical and Aerospace Engineering Department of the University of Patras (UP) has, since 1990, focused on educational and R&D activities involving composite materials and structures. Emphasis has been placed on anisotropic material property characterization, structural design and dynamics of composite rotor blades of wind turbines. Experience has been acquired by participating in several research projects funded by Greece and by the European Commission.

The UP has successfully completed structural designs for a 5.5-m and a 10-m GRP blade, the verification of which was performed by full-scale static and modal tests at the CRES blade testing laboratory. During 1998, in the framework of the EPET-II National Program, a 19-m GRP rotor blade was designed by UP and is currently under construction by a Greek industrial partner, Geobiologiki S.A.

In the JOULE-III program, UP is participating in the project “AEGIS-Acoustic Emission Proof Testing and Damage Assessment of W/T Blades” by contributing to the design of small blades and failure characterization of composite materials using advanced numerical techniques for pattern recognition and analysis of NDT signals. UP is also participating in the project “ADAPTURB-Adaptation of Existing Wind Turbines for Operation on High Wind Speed Complex Terrain Sites; kWh Cost Reduction,” mainly contributing in numerical prediction of blade structural integrity under prescribed static and fatigue loading.

Other research activities of the Applied Mechanics Section are

(a) fatigue failure prediction of multidirectional laminates under combined stress state and variable amplitude loading,

(b) probabilistic design of composite structures and,

(c) fatigue characterization of composite materials using non-destructive testing.

The Electrical Engineering Department of NTUA has been actively involved in the field of wind energy since the beginning of the 1980s, participating in R&D projects sponsored by the European Union and other institutions and co-operating with universities and research centers from many European countries.

In 1998, the Electric Power Division of NTUA focused its research activities on issues relating to the power quality of wind turbines and wind parks, the technical constraints and problems in the integration of wind power into the electrical grids, the design of electrical components for variable speed machines, and grounding systems for lightning protection.

In collaboration with the Fluids Division of NTUA and CRES, codes for simulating the IEC electrical and control fault tests are being developed to permit accurate evaluation of the behavior of grid-connected wind turbines in case of electrical faults of any type.

In the field of power quality, the investigations continue, including the implementation of a flicker meter algorithm according to the IEC standards and the evaluation of the flicker severity of various types of wind turbines, fixed or variable speed. Algorithms for evaluating the slow voltage variations caused by wind parks are also available.

In collaboration with CRES and the Greek industry, the design of a 20-kW variable speed wind turbine equipped with a permanent magnet synchronous generator and state-of-the-art electronic converters is under way. The contribution of the Electric Power Division mainly focuses on the design of the electrical generator, the converters, and the associated controls.

Other activities include the analysis and design of grounding systems used for the lightning protection of wind turbines, as well as the development and implementation of GIS-based algorithms for optimal site selection of wind parks and their integration in the distribution networks.

13.6.2 Demonstrations

The main demonstration programs in wind energy currently under way in Greece are financed within the framework of the THERMIE Programme of the European Union. The following demonstration projects were on-going in 1998.

1. Large advanced autonomous wind/diesel/battery power supply system in Kythnos (THERMIE Programme). The aim of this project is to demonstrate the technical feasibility of integrating a very high penetration of wind energy into large supply systems. This large modular system for the island of Kythnos combines diesel generator sets, battery storage, a rotating phase shifter, five small wind energy converters, and one additional large wind energy converter. This large wind energy converter with a power output of 500 kW will supply a great portion of the power demand. It will be the first time that 50% of energy demand will be met by wind turbines. Thanks to the wind turbines, the diesel generators can be stopped when the power output of the wind turbines is sufficient. Furthermore, the 100-kW PV system and the 5 Aeroman 33-kW energy converters will be integrated into the wind/diesel/battery system. The project will be carried out by PPC and SMA. The wind turbine was erected in mid 1998 but the commissioning was delayed due to the complexity of the system.
2. A 2.5-MW wind farm in the island Mytilini (THERMIE Programme). The project concerns the installation of a 2.5 MW wind farm on the island of Mytilini, located in the North Aegean sea. The wind farm will consist of five 500-kW, variable-speed, pitch-regulated wind turbines, manufactured by Enercon. The power performance of the wind farm will be monitored and evaluated in relation to local grid penetration capability. Measurements of the wind potential in the area have been conducted during 1997–1998. Construction work is expected to start early in 1999.
3. Autonomous Wind-Desalination system on the island of Therasia (APAS Programme). The project concerns the installation of an autonomous wind powered small desalination system in Therasia. Therasia is a small island in the Aegean Sea, very close to the island of Santorini. The desalination system is based on Reverse Osmosis

technology with a nominal water production capacity 5m^3 per day. The wind turbine, manufactured by Vergnet SA, has a rated power of 15 kW. Purpose of the project was to demonstrate the feasibility of developing off-grid autonomous wind desalination units in remote areas. The monitoring phase of the project is currently ongoing.

4. CRES 2.5-MW Wind Farm in complex terrain (National Operational Program of Energy) The wind farm will comprise five different types of wind turbines with rated capacity from 500 kW to 750 kW each. The purpose of the project is to study the effects of complex topography on the performance of the wind turbines as well as of the overall wind farm. The project is within the National R&D program and the first machine will be erected in mid 1999. All the machines are expected to be commissioned in 1999.

5. A 300-kW induction wind turbine connected to the desalination plant of Mykonos Island (THERMIE Programme). The aim is to couple a medium-size wind turbine to a desalination plant and to have the option of operating it as a standard grid-connected machine, if necessary. During 1998, site preparation was executed. A NTK 300-kW wind turbine manufactured by NEG Micon will be installed in mid-1999.

6. A 500-kW wind turbine direct coupled to a desalination plant on Syros Island (JOULE-THERMIE Programme). An Enercon E40 500-kW wind turbine was installed on the Island of Syros, the capital of the Cyclades Islands, late in 1998. The aim of the project, which is managed by the National Technical University of Athens, is to demonstrate the successful operation of a wind-desalination system. The wind turbine is directly coupled to a desalination plant of 900m^3/day capacity. The grid connection alternative has also been foreseen. The commissioning of the wind turbine is currently ongoing.

CHAPTER 14

14.1 GOVERNMENT PROGRAMS

14.1.1 Aims and Objectives

In Italy, the share of electricity generated from renewable energy sources (RES) is currently around 22% of yearly domestic production. For the most part, this energy is provided by hydro-electric and (to a lesser extent) geothermal plants. For several years now, however, the Italian government has also taken an interest in new RES such as wind, solar energy and biomass with a view to increasing diversification and security of supplies, improving the balance of trade (Italy depends heavily on imported fuels and has also bought nearly 15% of its electricity demand from abroad in recent years), safeguarding the environment, and providing new opportunities for employment and social development.

As far as wind energy is concerned, in the past the Ministry of Industry, Commerce and Trade (MICA) co-ordinated a number of research and demonstration programs carried out by the state agency ENEA (the Italian National Agency for New Technology, Energy, and the Environment) and the electricity utility company Enel S.p.A., formerly the Italian National Electricity Board.

As to the most effective measures so far taken to deploy commercial wind farms, special mention is to be made of Directive No. 6 issued by CIP (the Interministerial Committee for Prices) on 29th April 1992. This Directive provided for premium prices to be paid for electricity fed into the grid from RES or from other sources recognized as “assimilated” (e.g. combined heat and power plants). These incentives raised a striking surge of interest among private investors, who presented MICA with a large number of wind farm projects. At present, however, the benefits of CIP No. 6/92 have been limited to plants already in operation or under construction at the beginning of 1997—721 MW of wind projects ranked by MICA in its first six classifications (those drawn up before 30th June 1995). A part of these projects has already been implemented, thus contributing to the growth of Italy’s wind capacity. Hopefully, the whole 721 MW capacity should come on stream following the Program Agreement signed in 1998.

More recent projects (such as the 1,498 MW wind capacity in the last 3 MICA classifications) have not been entitled to any premium energy price. New provisions like CIP No. 6/92 are only intended for really renewable sources (thus leaving out the so-called assimilated sources). They have long been awaited by developers but have not yet been issued. In 1998, however, two major events took place in Italy which are likely to have a strong, positive effect on the deployment of RES.

The first event was the National Conference on Energy and the Environment, held in Rome on November 25–28, 1998, which was organized by ENEA with the support of the Italian government. During the conference some major initiatives (already adopted or under discussion for approval in the Parliament) concerning, in different ways, RES dissemination, were illustrated and debated at length. The main topics were the following.

1. The reorganization of the electricity sector.
2. The resolution of CIPE (Interministerial Committee for Economic Planning) aimed at pursuing the targets of the Kyoto protocol.
3. The levying of a carbon tax.

4. The signing of the Agreement for Energy and the Environment by a large number of public and private bodies.
5. The publishing of a White Paper on RES by ENEA in co-operation with the main subjects involved in this sector.

The second major event was, in late 1998, the Decree on the electricity market drafted by the Minister of Industry to implement the European Union's Directive 96/92/EC giving common rules for the EU internal market. Based on the general principles of the Directive, this Decree has actually taken one of Europe's more advanced steps towards liberalization of the electricity sector, where Enel has so far had a predominant role in Italy. Among the chief points of the Decree (under discussion in the Parliament in early 1999), it is worth mentioning that no company should be allowed to control more than 50% of Italy's production, an independent body should be entrusted with energy dispatching over the national transmission grid, "eligible" customers could choose their energy suppliers among producers on the market, and the whole distribution sector should be streamlined, with separation between network operations and energy sales. As for RES, among others, a particularly promising point can be found in Article 11, which states that those who import or produce more than 100 GWh/year should be obliged to generate (or buy) 20% of their energy from RES (renewable portfolio standard).

14.1.2 Strategy and Targets

Regarding RES, the Government's plan is to follow the proposals introduced in the aforementioned national White Paper on RES, the main goal being to double the RES contribution to the energy balance within 2010. This requires an increase in Italy's energy production from RES up to 24 Mtoe in comparison with 12.7 Mtoe of 1996. To achieve this goal, the Decree will support the electricity market by adopting the renewable portfolio standard. Further support for RES production will ensue from the recent stipulation of the Program Agreement among Government, Regions, ENEA, Enel, Operators, Italian Bank Association, and others. The aim of this stipulation is to bring on line, by the end of 2001, RES plants (totaling 2,300 MW) that are entitled to the premium energy price granted by CIP Directive No. 6/92.

According to this strategy, wind energy should therefore play an important role, and approximately 3,000 MW of wind power capacity is the target currently set for Italy by 2010.

There also exist plans and targets at Regional level in favor of RES, and in particular of wind energy. For the time being, these have been implemented by Apulia, Campania and Sicily within the framework of plans named POP (Programmi Operativi Plurifondo). In particular, Apulia and Campania have funded some wind farms (already built) with the help of the European Union. In Sicily, RES plants financed by the same means will be realized during 1999. Wind farms on Sicily totaling 55.2 MW have obtained building permits and financing, but all the projects still must have an agreement with the utility Enel S.p.A. for grid connection.

14.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

14.2.1 Installed Wind Capacity

During 1998, 153 wind turbines corresponding to 79.7 MW were installed in Italy—a very large increase over the previous year (Figure 14.1). Turbines were put in service in the Val Fortore area, in the province of Benevento (Campania Southern Italy); 20 turbines (320-kW Lambda machines made by WEST of the Ansaldo Group) located at Monte Arci in Sardinia; and 10 turbines (350-kW M30-S2 machines made by Riva Wind Turbines RWT, a subsidiary of Riva Calzoni) installed at

San Benedetto Val di Sambro, in the Apennines in the Bologna province (Emilia). The S. Benedetto wind farm is the first one ever built in Northern Italy.

Almost all the turbines installed in Val Fortore are very close to one another, so it is practically impossible to distinguish visually which municipality and wind farm project they belong to. The terrain, at 850-950 m a.s.l., is pretty flat. The installations include 20 Enercon E-40 units, 500 kW each; and 95 Vestas V-42 and V-44 units, rated at 600 kW, manufactured by Vestas and Italian Wind Technology (IWT, a joint venture of Vestas and WEST). The Enerconones are operated by Riva Wind Power (RWP, formerly a subsidiary of Riva Calzoni and currently controlled by Edison), the latter ones are run by Italian Vento Power Corporation (IVPC). Also in Val Fortore, an additional eight M30-S2 machines have been installed by RWP and ISMES (a company of the Enel Group) in a small area on a mountain top.

At the end of 1998, Italy's total wind capacity was 180 MW (see details in Table 14.1). More increases in capacity are expected in 1999. Even during the winter of 1998–99 civil engineering work (depending on weather conditions) is in progress at sites in the Benevento and Foggia provinces. IVPC, RWP alone or in partnership with ISMES, and Filippo Sanseverino are the private investors engaged until now.

14.2.2 Plant Type

IWT, with its 65 machines installed in 1998, is now becoming the largest manufacturer acting in Italy's wind sector. The turbines produced are V-44 machines, rated at 600 kW, and have, until now, been mounted on a lattice tower 50 m high.

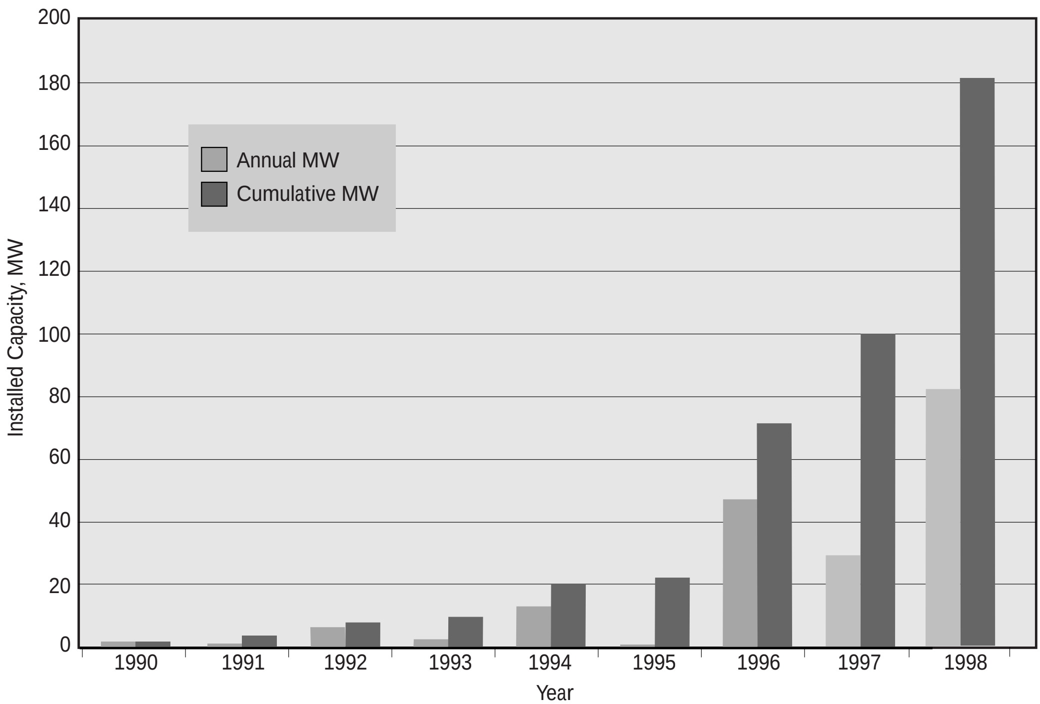

Figure 14.1 Trend of Italy's Installed Wind Capacity in Recent Years

Table 14.1 Grid-Connected Wind Plants Installed in Italy

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Alta Nurra	ENEL S.p.A.	Nov. 89	1	M30	200	33	33	0.20
		Mar. 91	1	MS-3	300	33	25	0.30
		Apr. 91	1	WD34	400	34	32	0.40
		May 92	1	GAMMA 60	1500	60	66	1.50
Bisaccia	Regione Campania	Jan. 92	4	Lambda	320	33	26	1.28
		Apr. 93	2	MEDIT I	320	33	26	0.64
		Jan. 92	3	AIT-03	30	10	12	0.09
		Apr. 93	13	AIT-03	30	10	12	0.39
Bisaccia	Alenia Rei		2	Lambda	320	33	26	0.64
Bisaccia	Com. Montana Pen. Sorrentina	Apr. 93	2	MEDIT 1	320	33	26	0.64
Palena (Sangro)	Consorzio Bonifica del Sangro	Feb. 94	3	MEDIT I	320	33	26	0.96
		Feb. 94	1	VESTAS V27	220	27	31	0.22
		Feb. 94	1	VESTAS V20	100	20	24	0.10
Acqua Spruzza (Frosolone)	ENEL S.p.A.	Winter 94	2	M30	200	33	33	0.40
		Winter 94	2	MEDIT I	320	33	26	0.64
		Winter 94	2	MS-3	300	33	25	0.60
		Winter 94	2	WD34	400	34	32	0.80
Frosolone	Comunità Montana Sannio	1994	1	MEDIT I	320	33	26	0.32

Table 14.1 Grid-Connected Wind Plants Installed in Italy (continued)

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Carloforte	N.A.	June 94	3	Lambda	320	33.0	26	0.96
Monte Uccari (Nurra)	Consorzio Bonifica di Nurra	End 94	5	Lambda	320	33.0	26	1.60
San Simone (Nurra)	Consorzio Bonifica Sardegna	Jan. 93	1	M30	200	33.0	33	0.20
Brunestica (Nurra)	Consorzio Bonifica di Nurra	1994	3	MEDIT I	320	33.0	26	0.96
Tocco da Casauria	Comune	June 92	2	M30	200	33.0	33	0.40
Campanedda	Consorzio Bonifica di Nurra	1994	4	M30 A	250	33.0	33	1.00
Ottava	Consorzio Bonifica di Nurra	1994	4	M30 A	250	33.0	33	1.00
Villacidro (CA)	Consorzio Industriale	N.A.	2	HMZ	200			0.40
		Spring 87	2	HMZ	160	21.8	23	0.32
		1995	2	Vestas V27	225	27.0	31	0.45
Villa Favorita	Società Villa Favorita	N.A.	1	HMZ Windmaster	150	21.8	23	0.15
Collarmele (AQ	Marsica Gas	July 93	1	Riva M30 A	250	33.0	33	0.25

Other wind turbine models operating in Italy are the single-bladed M30-S2 (350 kW) by RWT, the Lambda (320 kW) by WEST, the V-42 (600 kW) by Vestas, and the E-40 (500 kW) by Enercon. Some Bonus units of 600 kW each will be located in the Benevento province in 1999.

The average size of the turbines installed in 10 wind farms, during 1998, was 520 kW, a little more than in 1997. The total number of turbines in Italy rose to 403 by the end of 1998, with an average rated power of 446 kW.

A little less than 50% of installed machines were manufactured in Italy (Figure 14.2) and such percentage should increase in the next two, three years, since IWT is now in a position to provide the highest contribution, in terms of number of turbines and rated power, to wind plant deployment in Italy.

14.2.3 Installed Conventional Capacity

The conventional net generating capacity in Italy totals nearly 70 GW, of which over 56 GW belong to the utility Enel S.p.A.

14.2.4 Performance

Italy's electric energy production from wind plants totaled 231 GWh in 1998. Production in the Foggia and Benevento provinces (where most wind farms belong to IVPC) was particularly good and better than at other Italian sites. Here, load factors were often around 0.28. Machine availability was generally more than 95%, and even reached 99% at some sites in the last months of the year. The two 600-kW turbines operated by Filippo Sanseverino also had good performance with a load factor approaching 0.25.

Regarding reported failures or accidents, only a rotor was damaged very seriously by lightning at the Sant'Agata di Puglia wind farm and a few electric generators have been replaced.

14.3 MANUFACTURING INDUSTRY

14.3.1 Manufacturers

At the moment, three wind turbine manufacturers are acting in Italy: RWT, WEST and IWT; all their factories are situated in the Apulia Region. Another manufacturer of small machines began its activity in 1998, in the same Region.

RWT

About 20 turbines were manufactured, during 1998, by RWT (Riva Wind Turbines, a subsidiary of Riva Calzoni) in the factory of Foggia, where 14 people are engaged in assembling and testing the nacelle of the single-bladed M30-S2 machine. In 1999, a

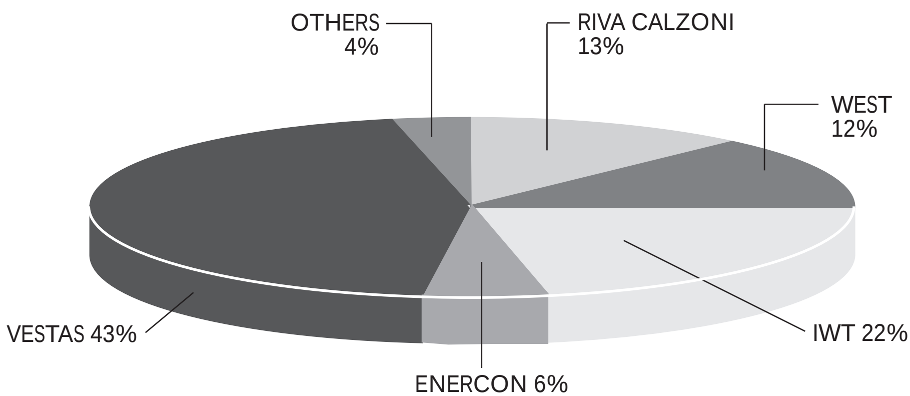

Figure 14.2 Manufacturer's Market Share of all Wind Turbines Installed in Italy at the end of 1998

larger number of turbines will be produced and installed in Apulia and, perhaps, in Basilicata, Tuscany, and Campania.

WEST

The completion of Enel's Monte Arci wind farm, made up of 34 Lambda machines totaling around 11 MW, was achieved. Previously installed 320-kW Medit units were replaced by the new Lambda version, a machine also rated at 320 kW, but equipped with a teetering hub. The company is also involved in the characterization of wind sites and some other activities with local administrations.

IWT

As a result of a long negotiation, Vestas and WEST have set up a 50/50 joint venture to manufacture Vestas wind turbines in Italy. The name of the new company is Italian Wind Technology (IWT). It has begun its first phase of activity producing blades and assembling turbines from components supplied by Vestas of Denmark.

During 1998, 65 turbines were delivered by IWT to IVPC. From now on, a very high percentage of the Vestas V-44, 600-kW machines to be installed in Italy will be assembled in the IWT factory in Taranto. One hundred people are currently employed, and, after reorganization of the factory, annual production of more than 150 wind turbines is anticipated.

Support and Component Industry

Several consultants and component suppliers give an important contribution to the development of wind technology in the country. The main Italian and foreign firms are: Garrad Hassan & Partners (consultant); Flender, Hamsen, Valmet (gearboxes); Leroy-Somer, ABB, Weier (generators); Atout Vent (blades); Elettroadda, Magrini Galileo (electrical components); Monsud (lattice towers);and Siderpali (tubular towers).

14.3.2 Wind Plant Investors

IVPC

At the end of 1998, the IVPC share of the Italian wind market reached 65% (Figure 14.3) and this percentage should increase in 1999 and 2000, according to the latest forecasts. During1998, work was concentrated in Val Fortore, where little less than one hundred units, supplied by Vestas and IWT, were set up. The people directly employed by IVPC are around 50, but many more are engaged in civil engineering work, construction of lattice towers, installation of electrical substations, etc.

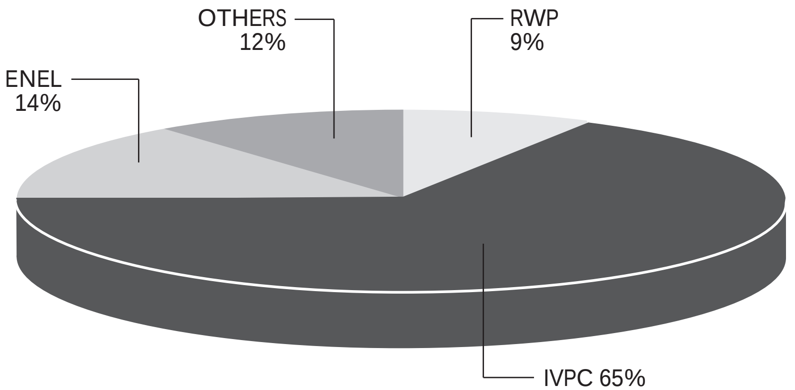

Figure 14.3 Contribution by Electricity Producers to Wind Power in Italy at the end of 1998

The next step of IVPC (Italian Vento Power Corporation) concerns the completion of installation of another 30 turbines, totaling 18 MW, in Val Fortore, anticipated in January 1999. Then, in February, activities will start at Alberona for adding 30 MW to the former windfarm already operating at this site in the Apulia Region.

RWP and Edison

RWP (Riva Wind Power, formerly set up as a subsidiary of Riva Calzoni) is the second investor in Italy, in terms of capacity. In November 1998, a 3.5-MW wind farm made up of 10 single-bladed, M30-S2 units was inaugurated in Northern Italy and, in December, 20 Enercon 500-kW turbines were connected to the grid in Val Fortore (Campania).

On December 2, 1998, Edison, the lead company of the Montedison Group in the energy sector, also got involved in the wind market by acquiring 60% of the stock of RWP. According to the Edison strategy, this is the first step of a development plan in the sector of renewable sources, in Italy and abroad, for the next five years.

Filippo Sanseverino

At the end of 1998, Filippo Sanseverino began the construction of a 30-MW wind farm. So far work has been in progress, and 16 Bonus 600-kW machines will be installed and connected to the grid in February 1999.

The Enel Group

The Enel Group (including the Enel utility and some subsidiaries such as ISMES) has already taken some steps to implement a commercial policy in the wind energy field. Specifically, in 1997 ISMES signed an agreement with Riva Calzoni by which ISMES joined in three wind-farm projects launched by Riva Calzoni (now RWP). These three wind farms are to be built in Southern Italy for a total capacity of 22.4 MW. A first cluster of 2.8 MW (with eight, 350-kW M30-S2 machines made by RWT) became operational at Foiano di Val Fortore (Campania) in1998 (See Figure 14.4).

The Enel Group has also been considering further possible wind-farm projects. In particular, for eight sites in Sicily and Southern Italy totaling a potential of about 100 MW, projects are already at an advanced stage as far as permitting and designing aspects are concerned. Plant construction could get started in a short time if suitable conditions were ascertained from the point of view of energy and / or capital cost subsidies and bank financing.

14.4 ECONOMICS

In this report, currency conversion has been made assuming 1 USD = 1650 ITL.

In Italy, electricity is currently sold to final customers at prices that can vary over a wide range depending on quite a large

Figure 14.4 Erection of 350-kW, M30-S2, Single-Bladed Wind Turbines at Foiano di Val Fortore (Campania)

number of variables. Roughly speaking, the selling price to typical domestic consumers ranges from ITL 100 to ITL 300/kWh (USD 0.06 to 0.18/kWh). The selling price to industrial consumers ranges from ITL 90 to ITL 180/kWh (USD 0.05 to 0.11/kWh). These are all net prices without taxes.

According to CIP Directive No. 6/92, buying prices for wind generated electricity fed into the grid, were fixed in 1998 at these two levels:

ITL 202.4/kWh (USD 0.123/kWh) for the first eight years of plant operation (on condition that the plant makes available its whole capacity or a fixed share of it)

ITL 102.8/kWh (USD 0.062/kWh) for the remaining lifetime.

According to CIP 6/92, in case of subsidies to capital cost, the extra amount is to be reduced, in 1998, by ITL 38.3/kWh, thus bringing the overall price down to ITL 164.1/kWh (about USD0.099/kWh). As said, the above-mentioned CIP 6/92 prices are now actually available only for plants that were already operating or under construction in early 1997 or whose projects had been included in the MICA classifications before June 30, 1995.

The total project costs are strongly dependent on the size of wind-farms and the characteristics of sites and grids. In Italy, the costs given by investors for the latest wind-farm projects are in the range of ITL 1.8-2 million/kW (about USD 1,100-1,200/kW).

The ex-factory cost of the 350-kW, RWT M30-S2 wind turbine is around ITL 480 million (more or less USD 290,000), while the cost of the 600-kW, IWT V-44 turbine produced in Taranto (nacelle and blades) is about ITL 600 million (about USD 364,000), not including the 50 m lattice tower cost, more or less ITL 100 million (around USD 60,000).

14.5 MARKET DEVELOPMENT

14.5.1 Market Stimulation Instruments

In addition to market stimulation measures already dealt with in the foregoing (such as CIP 6/92 provisions), mention should be made here of the forthcoming government Decree on the electricity market, which is now under discussion in the Parliament for approval. In this Decree, some outstanding measures that can well help RES deployment have been introduced including the following.

1. Priority is assured to electricity from RES in energy dispatching over the transmission system,
2. Those who import or produce more than 100 GWh/year will be obliged to generate at least 20% of their energy from RES or to buy the same amount of energy from other RES producers or traders,
3. The authorization to build new power plants will be conditional upon construction of RES plants that contribute at least 1% of the energy fed into the grid,
4. The renewal of hydro-power concessions is granted subject to an increase in energy production or installed power,
5. RES will be given priority in the development of weak isolated networks,
6. For each RES, multi-year objectives will be set and resources for incentives will be assigned to Regions and Autonomous Provinces; these will also grant incentives from their own resources through competitions,
7. Operation of RES plants not exceeding 20 kW, even if connected to the grid, will be subject to simplified regulations and taxation.

As mentioned earlier, some Regions have also taken initiatives to boost RES deployment. Campania, Apulia and Sicily, through their Regional Plans named Programmi Operativi Plurifondo (POP), partially funded by European Union's Structural Funds, have supported or insured wind plant projects, until now, with around ITL 120 billion (USD 72.7 million). The contribution is awarded in variable percentages of the eligible cost.

14.5.2 Planning and Grid Issues

An additional cost item to be carefully considered by wind plant developers is that related to grid connection. All relevant technical and financial aspects have to be agreed with the utility involved (mostly Enel). According to CIP 6/92, one third of the cost of grid-connecting lines should be borne by the plant developer and two thirds by Enel (at least in areas with an energy deficit, as is commonly the case in Italy's wind-farming areas). Otherwise this ratio should be reversed.

In this respect it should also be recalled that developers intending to set up substantial wind capacities in the same area (as has happened in the Apennines area between Campania and Apulia) have been required by Enel to deliver their power directly into the 150-kV system. In these cases, Enel has shared grid-connection costs only as far as the 150-kV line is concerned, while developers have had to bear all costs of intermediate step-up sub-stations and lower-voltage power collection lines. With special regard to the Apennines area mentioned above, where even larger capacity is likely to be added shortly, Enel has recently designed a new power collection scheme. In this scheme, all wind farms will eventually feed their power into seven dedicated sub-stations, from which 150-kV dedicated lines will carry power up to the high-voltage (380 kV) transmission grid.

14.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

14.6.1 ENEA's R&D Program

The Italian government supported wind energy programs by financing ENEA activities in the RES sector through the Program Agreement between the Ministry of Industry (MICA) and ENEA. This Program Agreement, begun in 1994, closed at the end of 1998.

Funding

The budget of the activities carried out by ENEA in 1998 was around ITL 2.3 billion (USD 1.4 million).

Ongoing Activities

At the end of 1997 the Minister of Industry, Commerce and Trade, with the Minister of the Environment and the Minister of University and Technological & Scientific Research, entrusted ENEA to organize a new National Conference on Energy and the Environment in November 1998. National, institutional, industrial and social organizations participated.

The main goals of this conference were to evaluate the new conditions of energy problems in relation to the environmental objectives, occupation, European unification, and so forth; and to identify the energy policy guidelines and, in particular, the proper instruments in order to guarantee effective legislative measures (tariffs, fiscal measures, incentives and regulations).

The conference was a great success, in terms of participation, items developed and, in particular, for the importance of some engagements taken by the Government in energy and environmental fields, also through the signing of an Agreement with operators, social parts, users, and so forth.

ENEA, in this framework, could confirm, and add to its traditional activity in technological development and scientific research, the role of public instrument in the field of new technologies, energy and the environment, which provides a technical support to the public administration and, at the same time, is involved in the productive process of the country by transferring technological knowledge to small and medium industry.

Among the conference themes, one was devoted to renewable energy sources. In this framework, a very important goal regarding a Program Agreement for realizing renewable energy plants, as already said above, has been achieved. The first sector of such Program Agreement concerns wind energy, for which the completion of the 721 MW previously authorized is anticipated by 2001.

The main aims of the initiative are to overcome some barriers such as lack and weakness of the electric grid in the most promising windy areas, to define some general rules about the permission process, in order to get the authorization for installing wind farms in a shorter time, and finally to establish with ABI (Italian Bank Association) better and clearer conditions of project financing. Before the Conference in November, an important meeting on renewables was held in Naples on June 4–5, 1998. The meeting was attended by the Minister of the Environment, the President of Enel, a member of the Regulatory Authority for Electricity and Gas, with over 700 representatives of industry, university, public administration. Several topics were presented, with a particular emphasis on the opportunities for economy and enterprise, taking into account environmental aspects.

In the meantime, ENEA has also been involved in other activities concerning siting, wind tunnel testing, as well as an information campaign in the wind energy sector, giving the support requested by the public administration. Information on wind energy is another activity in which ENEA has been involved, since schools and local Administrations are very interested in improving their knowledge in the sector.

In 2000, the next European Seminar on Offshore Wind Energy OWEMES, jointly organized by ENEA and the Italian Association of Naval Engineering (ATENA) will be held in Sicily.

14.6.2 ENEL's R,D&D Program

The electricity utility Enel S.p.A. has, for several years now, been involved in wind energy research and demonstration through its R&D Department (SRI). At present, these activities are gradually slowing down while the company is turning to a more commercially-oriented attitude even as far as wind energy is concerned, following its transformation into a joint-stock company, and the new trends in Italy's electricity market. Although SRI will remain in charge of some research and technology monitoring also in the next few years, Enel is now mainly considering the undertaking of wind-farming ventures that can be financially profitable.

Funding

The expenditure borne by ENEL for R, D&D activities on wind energy in 1998 was around ITL 8.73 billion (USD 5.3 million). The 1999 budget is around ITL 4.52 billion (USD 2.74 million).

Ongoing Activities

In early 1998, after several months of experimental operation under the supervision of SRI, the 9-MW demonstration wind farm of Collarmele in Abruzzo (36 machines supplied by Riva Calzoni) was taken over by Enel's Production Division as a regular generating plant. On the whole, the performance of this plant has since been reported as fairly satisfactory, with an energy yield in accordance with the foreseen amount of 14 Gwh / yr.

This year also saw installation of the 34 machines at the 11-MW Monte Arci demonstration wind farm in Sardinia (Figure 14.5). This plant was originally to be equipped with Medit machines manufactured by WEST. Construction work suffered considerable delay after WEST found problems with Medit machines already operating at other, non-Enel sites. This led WEST to develop a new version of Medit, named Lambda that featured a teetering hub instead of the previous fixed hub plus a number of other improvements. Commissioning tests and preliminary operation were in progress at Monte Arci all through 1998, following SRI's request to adjust and monitor carefully these units, which were actually new machines, before taking them over. This wind farm, too, is now going to be transferred to Enel's Production Division for regular operation.

Performance monitoring and structural stress measurements have continued at the Acqua Spruzza mountain test site (hosting eight machines totaling 2.5 MW) with special attention to the behavior of wind turbines and instruments in winter months. Experience has further confirmed that wind turbines have to face peculiar problems in such an environment (1350 m a.s.l.), mainly ensuing from icing, sudden snowfalls, heavy turbulence and lightning.

As for the Alta Nurra test site in Sardinia, the medium-sized machines have been partly operated and partly stopped; the latter ones are going to be dismantled. The 1.5-MW GAMMA60 prototype made by WEST has been out of operation since mid-1997, as SRI is no longer interested in experiments on this machine. Three stand-alone systems have also been under test; one of them is equipped with a small wind turbine and two are of the hybrid type (wind and photovoltaics).

Besides completing ongoing R, D&D activities, SRI has also provided technical assistance to commercial joint ventures undertaken by the Enel Group through ISMES for 22.4 MW projects. Other possible wind-farm projects already available for the Enel Group for a total of about 100 MW have been based on wind surveys and siting work carried out by SRI. As in previous years, in 1998 SRI also took part in a number of international wind energy research projects funded by DG XII of the European Commission.

Figure 14.5 Partial View of Enel's Monte Arci Wind Farm in Sardinia, With 35 Lambda Machines Totaling 11 MW

CHAPTER 15

15.1 GOVERNMENT PROGRAMS

15.1.1 Aims and Objectives

At the UN Climate Change Conference in Kyoto, in December 1997, the Japanese government agreed to reduce the output of greenhouse gases by 6% by 2008–2012 from 1990 levels. In September 1998, the government adopted a new energy supply plan to stabilize CO_2 emissions by 2010 as shown in Table 15.1. In a simulated case, the ratio of petroleum could be reduced from 55.2% (1996 level) to 47.2% (2010), while that of new energy sources could be increased from 1.1% to 3.1%. Wind energy is included in the new energy sources.

15.1.2 Strategy

Since 1978, after the oil crisis, the Japanese government has conducted its wind energy R&D program aiming at energy security. This is a part of a general R&D Program for renewable energy called the "New Sunshine Project." It is directed by the New Sunshine Program Promotion Headquarters (NSS H.Q.) in the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI). After concern about Global Warming arose, the New Sunshine Project's objective became to develop innovative technology to create sustainable growth, while solving both energy and environmental issues.

In 1995, MITI started a new subsidy system, the "Field Test Program" to stimulate the introduction of wind energy plants. This program played a remarkable role in introducing wind energy to the people. The Law on Special Measures for Promotion of Utilization of New Energy (New Energy Law) was enacted in June, 1997. This law made wind businesses suppliers of grid-connected energy for the first time in Japan, although wind farms are not considered as independent power producers.

15.1.3 Targets

The original target for wind energy

Table 15.1 The New Primary Energy Supply Plan by 2010

	1996		2010 (CONTINUOUS CASE)		2010 (STIMULATED CASE)	
Total Supply	597.00 Gl*	Ratio (%)	693.0 Gl	Ratio (%)	616.0 Gl	Ratio (%)
Petroleum	329.00 Gl	55.2	358.0 Gl	51.6	291.0 Gl	47.2
Coal	329.60 Mt*	16.4	145.0 Mt	15.4	124.0 Mt	14.9
Natural Gas	329.20 Mt	11.4	145.9 Mt	12.3	1.1 Mt	13.0
Nuclear	302.00 TWh	12.3	480.0 TWh	15.4	480.0 TWh	17.4
Hydro	82.00 TWh	3.4	105.0 TWh	3.4	105.0 TWh	3.8
Geothermal	82.10 Gl	0.2	105.8 Gl	0.5	105.8 Gl	0.6
New Energy	6.85 Gl	1.1	9.4 Gl	1.3	19.1 Gl	3.1

*gl = giga-liters in petroleum equivalent, Mt = Million ton in coal equivalent capacity in Japan was 20 MW by 2000 and 150 MW by 2010. Because this modest goal for wind energy capacity has already been attained, the government increased the goal in the latest Primary Energy Supply Plan from 150 MW to 300 MW for 2010.

15.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

15.2.1 Installed Wind Capacity

During 1998, 40 new units with 14,370 kW of total capacity were newly installed. This brings the cumulative installed capacity in Japan to 31.6 MW. This value exceeds the government's target of 20 MW by 2000. There are plans to install an additional of 87 turbines for an additional capacity of 68 MW in 1999. If these turbines are installed as planned, the cumulative capacity will be 100 MW by 2000 as shown in Figure 15.1. This is five times of the government's original target.

15.2.2 Installed Conventional Capacity

The demand for electric power generation in 1996 was 904 TWh. The contributions of the different primary energy resources in 1996 are shown in Table 15.3. Imported primary energy resources amount to 82%.

15.2.3 Plant Type

Out of a total of 71 plants, 32 are for R, D&D, 15 are for power supply, 22 are for wind business, research, and the remaining three are for display. The types of machines installed during 1998 are NEG-Micon 225–600 kW, MHI 300–500 kW, Enercon 230–500 kW, Lagerwey 80–250 kW, Vestas 225–600 kW, WindWorld 170 kW, Nordex 150–250 kW, Fuhrlander 130–300 kW. The size of newly installed machines is increasing year by year. Lagerwey 750-kW machines are now under construction. According to the proposed projects, around 50 units of 1-MW machines will be installed in 1999.

Table 15.2 Installation of WTGS in Japan

YEAR	TOTAL NUMBER OF UNITS	INSTALLED GENERATION (MW)	AVERAGE POWER IN kW PER UNIT
1989	9	0.358	39.8
1990	13	0.891	68.5
1991	14	0.991	70.8
1992	23	2.899	126.0
1993	35	4.982	142.3
1994	41	5.856	142.8
1995	54	9.496	175.9
1996	67	13.495	201.4
1997	80	17.198	215.0
1998	129	31.568	263.1
1999	207	99.358	480.0

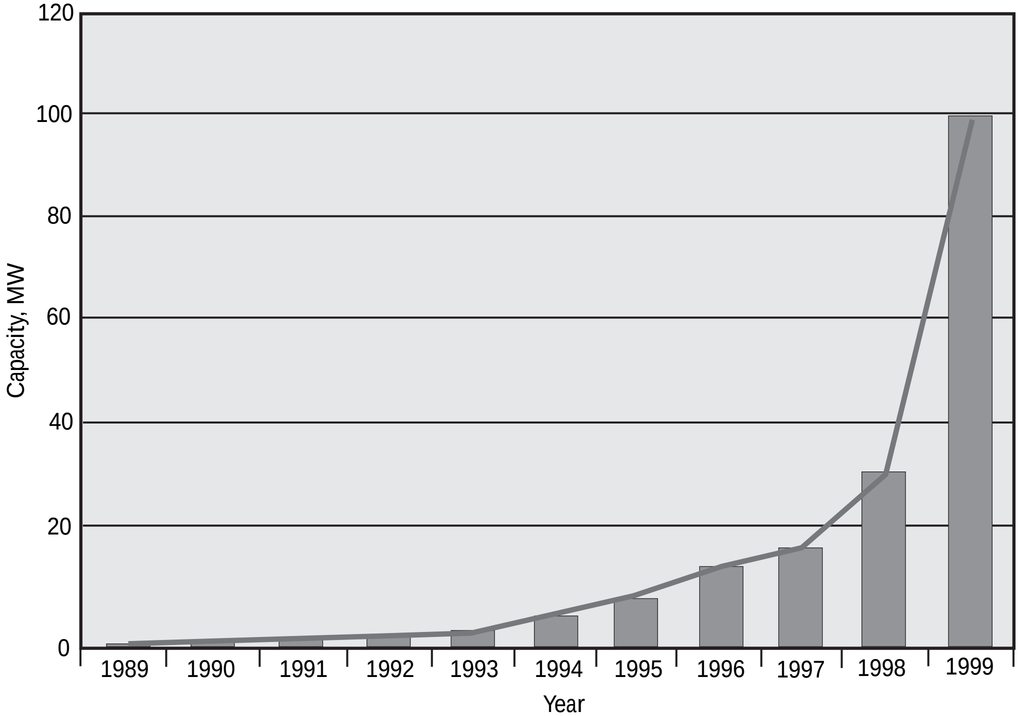

Figure 15.1 Time History of Installed Capacity of WECS in Japan

15.2.4 Forms of Ownership

There are five types of wind plant owners: manufacturers, research institutes, local governments, electric power companies, and private companies. Numbers of plants by ownership are: manufacturers: 3; research institutes: 6; local governments: 15; electric power companies: 22; and private companies: 25. Two windfarms of 20–30 MW capacity are planned by the private sector as wind businesses.

15.2.5 Energy Output

Statistical data on wind turbine operation are not collected systematically; however, NEDO will start collecting numbers in 1999.

Table 15.3 Supply Structure of the Primary Energy Resources of Japan (in 1996)

Contribution of Primary Energy Resources	Percent
Oil	55.2
Coal	16.4
Nuclear	12.3
Natural Gas	11.4
Hydropower	3.4
Geothermal	0.2
Renewable energy	1.1

15.2.6 Technical Performance

Table 15.4 shows the operational technical performance of the two largest wind power stations at Tappi and Miyako. Both stations have excellent annual mean wind speed about 8–10 m/s.

15.2.7 Operational Experience

No significant technical problems were reported, although Japan presents several siting problems. Japan is located in the main path of typhoons, is subjected to frequent earthquake, and experiences high turbulence at hilly sites. However, since rather many plants have recorded very poor capacity factors, siting and planning must be performed much more carefully.

15.3 MANUFACTURING INDUSTRY

The Japanese wind turbine manufacturers are Mitsubishi Heavy Industries, Ltd., Ishikawajima-harima Heavy Industries Co., Ltd., Houkoku Kougyo, Ltd., Matsumura Kikai-Seisakujo, etc. Other machinery manufacturers deal with foreign wind turbines as shown in Table 15.5.

15.4 ECONOMICS

Because it is still in the early stages of commercial development in Japan, a statistical evaluation of economics of wind generation can not be properly done. In general, wind energy generation has been considered to be about two times more expensive than conventional energy. However, the fact that a few wind farms are planned as commercial businesses in

Table 15.4 Operational Technical Performance of Wind Power Stations

	TAPPI WIND PARK (TOUHOKU EPC) MHI275 kW - 5 UNITS MHI300 kW - 5 UNITS		MIYAKO WIND POWER STATION (OKINAWA EPC) MHI250 kW - 2 UNITS NEG-Micon 400 kW - 3 UNITS	
Year/Month	Generation (kWh)	Capacity Factor (%)	Generation (kWh)	Capacity Factor (%)
1997/1	830,400	38.8	64,325	34.6
1997/2	671,200	36.3	391,590	33.1
1997/3	774,200	36.0	285,780	22.6
1997/4	603,000	28.9	223,721	18.3
1997/5	685,200	31.7	235,040	18.6
1997/6	421,700	20.1	230,910	18.9
1997/7	398,600	18.3	198,810	15.7
1997/8	483,100	22.3	318,230	25.2
1997/9	271,100	13.1	317,810	25.1
1997/10	599,200	27.8	308,690	24.4
1997/11	517,100	24.8	443,370	36.2
1997/12	794,100	37.0	437,330	34.6
1998/1	752,900	35.1	467,160	36.9
1998/2	656,500	35.5	338,970	29.7
1998/3	696,400	32.3	329,640	26.1
1998/4	578,600	27.6	263,940	21.6
1998/5	491,200	22.6	138,239	10.9
1998/6	779,100	37.3	293,730	24.0
1998/7	461,000	21.4	223,580	17.7

Table 15.5 Wind Turbine Manufacturers and Dealers in Japan

MANUFACTURERS OR DEALERS	WIND TURBINE TYPE
Mitsubishi Heavy Industries, Ltd.	MH1 250, 275,300, 500, 600, and 1000 kW
Ishikawajima-harima Heavy Industries Co., Ltd.	IHI 300 kW, Nordex 150, 250, 600, 800, 1000, and 1300 kW
Houkoku Kougyo, Ltd.	5.2 kW, Riva Calzoni 350 kW
Matsumura Kikai-Seisakujo	MWG-50, 300, and 800 kW
Hitachi, Ltd.	Enercon 230, 280,500,600,850, and 1500 kW Vestas 225, 500 and 600 kW
NEG-Micon, Ebara Co.	Neg-Micon 225, 400, 600, 750, 1000, and 1500 kW
NKK Co.	Lagerway 80, 250, and 750 kW
Iwatani Sangyo, Ltd.	DeWind 490, 600, 1000, and 1250 kW
Densei	Tacke 600 kW, Fuhrlander 40, 130, 300, 800 kW, FUH 70W – 10 kW

1999, implies that the economics of wind have improved.

15.4.1 Electricity Prices

Electric power companies purchase the surplus electricity from WTGS through contracts. The price is usually the same as that of household customers' contracts, between 14.44 yen/kWh and 18.10 yen/kWh, depending on the power company and the season. The Agency of Natural Resources and Energy estimated the cost of energy from wind generation as 32 Yen/kWh a few years ago. However, NEDO's Field Test Program has reduced the cost of energy to approximately 20 Yen/kWh. Furthermore, several new projects supported by NEDO's New Energy Business Supporting Program show estimated costs ranging from 8.6 Yen/kWh to 13.9 Yen/kWh, depending on the annual mean wind speed, capacity factor, and other external conditions.

15.4.2 Invested Capital

The installed cost of a wind plant ranges from 0.23 to 0.33 Mil-Yen/kW in the New Energy Business Supporting Program.

15.4.3 Turbine and Project Costs

On average, the ratio of the turbine cost to the project cost is 46% in the Field Test Program and 69% in the New Energy Business Supporting Program.

15.4.4 New Purchase Price System

Prior to 1998, wind turbine owners could sell surplus electricity to the power companies at a selling price around 15 yen/kWh with a contract period of 1 year. However, in 1998, the electric power companies agreed to new guidelines for purchasing electricity from wind turbines. In the new offering, the price is 11.5 Yen/kWh with 15-year contracts on average.

15.5 MARKET DEVELOPMENT

15.5.1 Market Stimulation Instruments

Aiming at developing 150-MW capacity by 2010, NEDO's Field Test Program, started in 1995, provides incentives for developing wind markets in Japan. This program has raised interest in wind energy among developers, local authorities, private companies, and individuals. The Japanese government doubled the capacity target for 2010 to help realize the target of CO_2 emissions reduction after the Kyoto protocol. In addition the New Energy Business Supporting Program stimulates development of wind business in the public sector and private sector. The minimum capacity of a wind power plant must be 800 kW for private business entities and 1200 kW for municipal corporations or companies connected with municipal corporations. The subsidy covers approximately 1/4 to 1/3 of the initial cost.

15.5.2 Planning and Grid Issues

In Japan, the problem of complex terrain affects the design of turbines. They must be designed for mechanical strength to withstand gusty and turbulent winds. The turbulent conditions also demand special designs to maintain high quality of electrical output. Complex terrain also increases the cost of transportation, erection, and grid-connection. In Japan, the most promising wind sites are located in regions with weak electric grids. Here the quality of electricity is very important and further technical developments are needed.

15.5.3 Impact of Wind Turbines on the Environment

There have been no severe objections to wind turbines on the basis of noise, visual impact, or risks to birds. But, quite recently, a group of the residents are opposing a new project.

15.5.4 Financing

There are several schemes that support wind developers by subsidy or tax reduction. Among them, NEDO's subsidy programs mentioned above are most influential.

15.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

The national wind energy activities in Japan are shown in Table 15.6.

15.6.1 Funding Levels

Table 15.7 shows the history of the budget of MITI for wind energy R&D in the NSS Project and Field Test / New Energy Business supporting Programs.

Table 15.6 Recent and Future National Wind Energy Activities in Japan

NATIONAL ACTIVITIES	PERIOD	ORGANIZATION/INSTITUTE
New Sunshine Project (R&D)	1978–	NSS-H.Q.
1. Wind resource measurement	1990/1994	NEDO
2. R&D of LS-WTGS (500 kw)	1990/1997	NEDO/MHI/Tohoku EPC
3. Demonstration of a MW-class wind farm	1991/1998	NEDO/Okinawa EPC
4. Generic, innovative R&D	1978–	MEL
5. Advanced WTGSs for remote islands	1999/2004	NEDO
6. Local wind flow simulation technology	1999/2003	NEDO
New Promotion Project	1992–	MITI
Field Test Program/new energy business support		NEDO
Standard	1988	MITI/JEMA/MEL/
IEC, ISO, JIS		Industries/etc.

Table 15.7 Budget for National Wind Energy Projects in MJPY

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999
NSS project	540	981	978	744	634	606	554	477	414
Field test/new energy business supporting programs	–	–	–	–	80	320	460	1529	1739
Total	540	981	978	744	714	926	1014	2006	2153

15.6.2 Priorities

1. New Sunshine Project: Research & Development, Demonstration:

   In 1978, the Japanese government started its wind energy R&D program that is a part of general R&D Program for renewable energy called "New Sunshine Project". It has been directed by the New Sunshine Program Promotion Headquarters (NSS H.Q.) in the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI),

   Activities in this program are described in Table 15.6. NEDO carries out the first three, while MEL undertakes the fourth. NSS will start two new R&D projects, shown as the 5th and 6th in Table 15.6. These two new R&D projects have focused on the wind technology for special Japanese conditions such as hilly or island areas of complex terrain with high turbulence,

2. Promotion of Introduction with Subsidies:

   NEDO's Field Test Program and New Energy Business Supporting Program promoted by MITI have played and continue to play an important role in promoting the introduction of wind turbines among private companies, as well as with local governments, as mentioned above,

3. IEC standard and JIS standard:

   The national programs include cooperation in the IEC Standard activities in the wind energy category. MITI is also promoting international consistency in standards. Therefore, there are plans to publish national JIS standards for wind turbine generator systems.

15.6.3 R&D Results in 1998

In March 1998, a MW-class wind farm (1,700 kW) on Miyako Island was demonstrated. The test data demonstrate satisfactory electrical quality—frequency variation below 0.3 Hz from 60.0 Hz at a penetration ratio of 12%. In March 1999, the R&D of LS-WTGS of 500 kW capacity will be completed. There have been no significant problems with these installations where large wind turbines were erected at hilly sites with high turbulence. These R&D installations demonstrate that the technology exists for introducing large-scale turbines rating at 500 kW or more into Japan.

15.6.4 New Concepts

Under the NSS's R&D Program, MEL has tested two fully flexible wind turbines—WINDMEL-I and WINDMEL-II. The research-operation of the WINDMEL-II demonstrated that the flexible design reduces mechanical stresses and helps to stabilize power output. This work will apply to NEDO's new R&D projects as well.

15.6.5 International Collaboration

The main activities are IEA Wind R&D cooperation and IEC standards development for wind turbine generators. Many individual international collaborations are also undertaken at research institutes and universities.

15.6.6 Wind Energy Resources

In 1994, NEDO completed an atlas of wind energy potential in Japan. The atlas displays three scenarios, from optimistic to rather realistic, as shown in Table 15.8.

Table 15.8 Wind Energy Potential

SCENARIO	Area km² (ratio to total land surface in %)	Number of Units (500 kW WTGS)	potential CAPACITY MW (ratio to total in %)	potential WIND GENERATION GWh (ratio to total generation in %)
1	23,280 (6.4%)	125,519–565,278	not completed	not completed
2	3,599 (1.0%)	18,430–70,481	9,220/35,240 (4.61%/17.62%)	8,916/34,127 (1%/3.84%)
3	759 (0.2%)	2,792–13,743	,440/6,870 (0.70%/3.43%)	1,325/6,537 (0.15%/0.74%)

CHAPTER 16

16.1 GOVERNMENT PROGRAMS

Specific plans for integrating a meaningful capacity of wind power plants into the national electric system have not been established. However, promoters of wind energy have pointed out that the exploitation of the main wind resource in Mexico could lead to installation of 3,000–5,000 MW of wind power plants. The main deployment of wind energy in Mexico could take place at the south of the Tehuantepec Isthmus in a 3,000-km^2 region known as "La Ventosa." Average annual wind speeds from 7 to 11 m/s at 30 meters above ground have been measured in this region. It is estimated that up to 2,000 MW of wind power plants could be installed there with technical and economic advantages. (See Figure 16.1).

In October 1998, an "International Seminar on Renewable Energy for Electricity Generation: Current State and Outlook" was held at the initiative of the Advisory Council for the Development of Renewable Energy (COFER) and the National Commission for Energy Conservation (CONAE). About 150 people attended the seminar, including participants from the Ministry of Energy (SE), the Federal Mexican Congress, the Federal Electricity Commission (CFE), the Energy Regulatory Commission (CRE), the Electrical Research Institute (IIE), the National Solar Energy Association (ANES), universities, financial institutions, and several private companies. International participants included delegates from the World Bank, the U.S. Agency for International Development, Natural Resources Canada, Winrock International, Lahmeyer International GmgH, and British Petroleum. General discussions on opportunities and constraints for deploying renewables in Mexico were held. It is expected that conclusions of this meeting can lead to favorable initiatives, which could emerge during 1999.

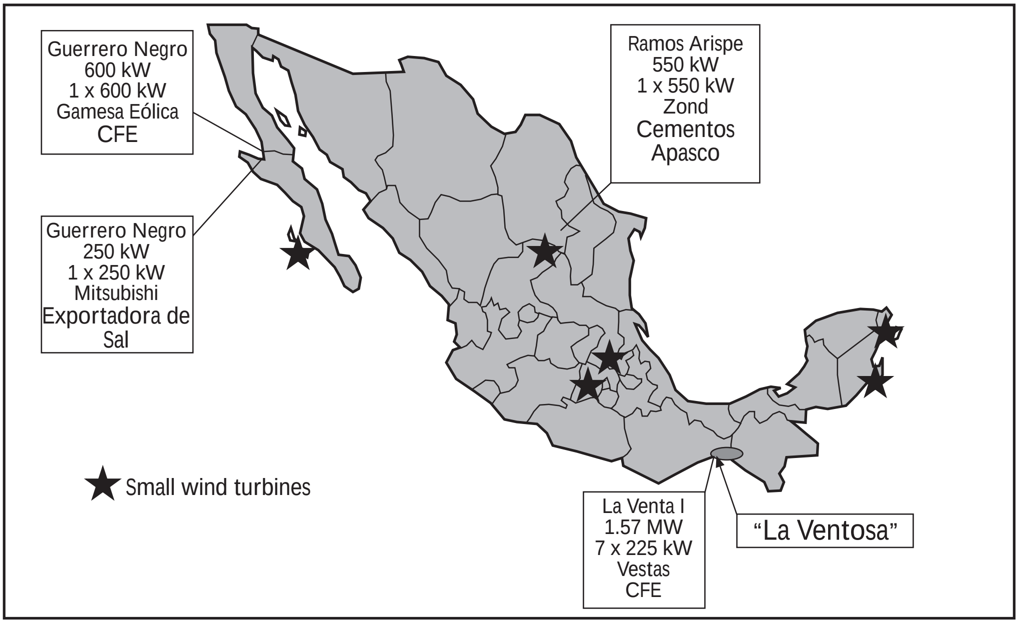

Figure 16.1 Distribution of Wind Turbine Installations in Mexico

16.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

In the third quarter of 1998, a 600-kW wind turbine was connected to a pre-existing diesel power station in the isolated village of Guerrero Negro in the middle of the Baja California Peninsula. The Federal Electricity Commission (CFE), owner and operator of the facility, undertook the project. The Spanish manufacturer Gamesa Eólica won the bid to supply and install the wind turbine. The diesel power station, which is rated at 16 MW, supplies electricity to an isolated grid that is located far away from the nearest point of connection to the electric system of Baja California. According to the CFE, the performance of the facility will be assessed in order to decide whether it is feasible to increase the wind capacity up to 3 MW.

By the end of 1998, the total installed capacity of wind turbines in Mexico was 3.1 MW. (See Table 16.1).

16.3 OPERATIONAL EXPERIENCE

Electricity production from "La Venta" wind power station was 5.18 GWh during 1998. The facility operated with an annual capacity factor of 37.6%. The overall availability was only 89.6%, due to failures on three wind turbines. In two of the machines, the gearbox failed due to inadequate shaft alignment when the electric generators were replaced by the manufacturer. One gearbox was repaired by the manufacturer, while the other was repaired by a Mexican company. In the third turbine, the electronic control box caught fire (this was the second occasion in which this kind of problem occurred in the plant). The operators of "La Venta" wind power station have gained experience on maintenance requirements; nowadays, a number of problems are being overcome solely with local technical support.

During the commissioning phase of the 600-kW machine recently installed at Guerrero Negro, automatic shutdowns happened due to an inbalance of reactive loads in the electric circuit. This problem has been solved.

Table 16.1 Wind Turbine Installations in Mexico by the end of 1998

LOCATION	MANUFACTURER	WIND TURBINES (kW)	CAPACITY (MW)	COMMISSIONING DATE	OWNER*
Guerrero Negro, B.C.S	Mitsubishi	1 x 250	0.250	1985	(1)
La Venta, Oax.	Vestas	7 x 225	1.570	1994	CFE
Ramos Arispe, Coah.	Zond	1 x 550	0.550	1997	(2)
Guerrero Negro, B.C.S.	Gamesa Eolica	1 x 600	0.600	1998	CFE
Small wind turbines					
Quintana Roo.		22	0.077		RC (3), PI (4)
Estado de Mexico		2	0.020		RC
Zacatecas		3	0.030		RC
Hidalgo		1	0.005		RC
Baja California Sur.		3	0.015		RC
Total		41	3.110		

* (1) Compañía Exportadora de Sal (salt producer); (2) Cementos Apasco (cement factory); (3) rural communities; and (4) private individuals

Table 16.2 Wind Power Plants under Negotiation

	PROMOTER	LOCATION	CAPACITY (MW)
1	Federal Electricity Commission (CFE)	La Venta, Oax.	54.0
2	Cozumel 2000	Cozumel, Q. Roo.	30.0
3	Gaja California 200	La Rumorosa, B.C.N.	60.5
4	Fuerza Eólica del Istmo	La Ventosa, Oax.	30.0
5	Electricidad del Sureste	La Mata, Oax.	27.0
6	Energía Renovable	La Ventosa, Oax.	240.0
		Total	441.4

The 550-kW wind turbine at Ramos Arizpe has been working without major problems. However, only a moderate wind resource is available at this site.

Construction of the 54-MW wind power station proposed by the Federal Electricity Commission since 1996 was postponed again. Another five projects, led by private companies, continue in the negotiation phase. (See Table 16.2). The Energy Regulatory Commission (CRE) has already issued permits to build projects 2 to 5; nevertheless, all these have to overcome some pending constraints before construction can be started. Project 6 is still in the promotion phase, but it is interesting to note that the proposal includes the construction of a wind turbine assembling facility in Mexico using Vestas technology.

16.4 INSTALLED CONVENTIONAL CAPACITY

The total installed conventional capacity in Mexico by the end of 1996 was 34,791 MW, made up of the following sources: oil (41%), hydro (28.8%), coal (7.5%), oil / coal (6%), oil / gas (5.5%), gas (4.8%), nuclear (3.8%), geothermal (2.1%), and oil / diesel (0.3%). Installed capacity is expected to grow by 13,182 MW in the period 1997–2006.

16.5 MANUFACTURING INDUSTRY

Except for a manufacturer of small (5-kW) wind turbines, there is no wind turbine manufacturing industry in Mexico. However, there is an increasing interest from private investors to establish wind turbine manufacturing joint ventures. According to a recent study by the IIE, several wind turbine components (e.g. towers, nacelle, electrical devices, cables, transformers, and others) could be manufactured in Mexico using existing infrastructure. It is expected that a meaningful level of activity in local integration of wind turbines could impel the deployment of wind energy in Mexico.

16.6 ECONOMICS

Electricity prices to consumers vary depending on the region, the time of day, and the supplied voltage. For electricity billing purposes, the country is divided into eight regions. Each region has its own timetable for electric tariffs over a 24-hour period. Table 16.3 shows ranges for medium and high voltage valid for the whole country.

In December 1998, domestic customers paid MP 0.346 for each of the first 75 kWh, MP 0.408 for each kWh in excess of the first 75 kW, and MP 1.19 for each kWh in excess of the first 125 kW. The tariffs for public lighting range from MP 0.82 to MP 1.02; this is an opportunity niche for wind energy.

No special buy-back price for wind energy has been set in Mexico. Therefore, electricity

Table 16.3 Examples of Electricity Prices in Mexico (in Mexican Pesos - December 1998)

TARIFF*	PEAK	INTERMEDIATE	BASE
HM (1)	0.85–1.06	0.29–0.40	0.23–0.29
HS (2)	0.79–1.10	0.26–0.36	0.22–0.27

* (1) HM–Hourly tariffs for general service in medium voltage (power ≥ 300 kW); (2) HS–Hourly tariffs for general service in high voltage (less than 400 kV)

from private wind-power plants would be paid by the CFE according to active tariffs. This implies that the revenues would depend not only on the amount of electricity fed into the grid, but also on the time of day the electricity is produced.

According to the CFE, project cost for “La Venta” wind power station was USD 1,357 per installed kW (1994). Detailed cost for the “Guerrero Negro” wind turbine has not been released yet, but it is known the cost was higher than USD 1,400 per installed kW (1998).

CHAPTER 17

17.1 GOVERNMENT PROGRAMS

17.1.1 Aims and Objectives

The Dutch energy policy aims at an overall stabilization of CO_2 emission and fossil fuel use (at the level of 1990). This is considered necessary because of the limits to fossil fuel resources, the increasing vulnerability of energy supply and international environmental problems, specifically imminent effects of climatic change. The energy targets are set down in the *Third Energy Memorandum*, issued in December 1995 by the Ministry of Economic Affairs.

In order to achieve these objectives, the philosophy of the Trias Energetica includes the following guiding principles.

1. First, limit energy demand as much as possible,
2. Then, meet the remaining demand with renewable energy and,
3. Finally, if fossil fuels are still required, use them as cleanly and efficiently as possible.

At present, less than 1% of Dutch energy consumption is met by renewable sources such as solar, wind, and water. The *Third Energy Memorandum* sets the targets for renewable energy to a 3% contribution in 2000 and a 10% contribution in 2020. The targets have been set in annual saving of fossil fuels, expressed in petajoules (See Table 17.1). The total national energy consumption is 2.700 PJ.

17.1.2 Strategy

The strategy to reach the targets of the *Third Energy Memorandum* is set down in the action plan *Renewable Energy on the March (DEIO)* published in March 1997 by the Ministry of Economic Affairs. This plan emphasizes the need to accelerate efforts of concerned parties and lists the measures required before 2000.

Table 17.1 Renewable Energy Targets in Annual Avoided Fossil Primary Energy (PJ)

SOURCE	2000	2007	2020
Wind Energy	16	33	45
Solar Energy PV	1	2	10
Solar Energy Thermal	2	5	10
Hydro Power	1	3	3
Biomass (incl. waste)	54	85	120
TOTAL RENEWABLES	74	128	188
Geothermal	0	0	2
Cold and Heat Storage	2	8	15
Heat Pumps	7	50	65
TOTAL SUSTAINABLES	9	58	82
RENEWABLES AND SUSTAINABLES	83	186	270

The required actions are the following.

1. Improve the price-performance ratio,
2. Stimulate market penetration,
3. Address administrative bottlenecks.

For a description of the measures that affect the wind energy program refer to the *IEA Wind Energy Annual Report of 1997*.

Table 17.2 Rough Estimate of Installed Capacity to Meet the Targets for Wind Energy

YEAR	CAPACITY MW	SAVED PRIMARY FUEL, PJ
1990	50	0.6
1995	250	4.0
2000	750	12.0
2007	2000	33.0
2020	2750	45.0

17.1.3 Targets

The governmental targets for wind energy are set in annual avoided fossil primary energy in petajoules (See Table 17.1). These can be translated into needed installed wind capacity (See Table 17.2). From the 2,750 MW in 2020, it is expected that about 1,250 MW will be installed offshore.

17.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

17.2.1 Installed Wind Capacity

In 1998, 60 wind turbines, with a total capacity of nearly 41 MW, were installed and nine wind turbines, with a total capacity of less than 2 MW, were removed. This brings the total operational capacity by the end of 1998 to 364 MW with 1,195 wind turbines and 864,595 m^2 swept area (See Figure 17.2).

17.2.2 Numbers / Type / Make of Turbines

The average installed capacity per wind turbine in 1998 was more than 680 kW, the average ratio, between swept area and capacity was 2.5 m2 / kW, and the average hub height was 50 m.

Of the installed capacity in 1998, almost 50% was manufactured by Dutch manufacturers, as is shown in Table 17.3.

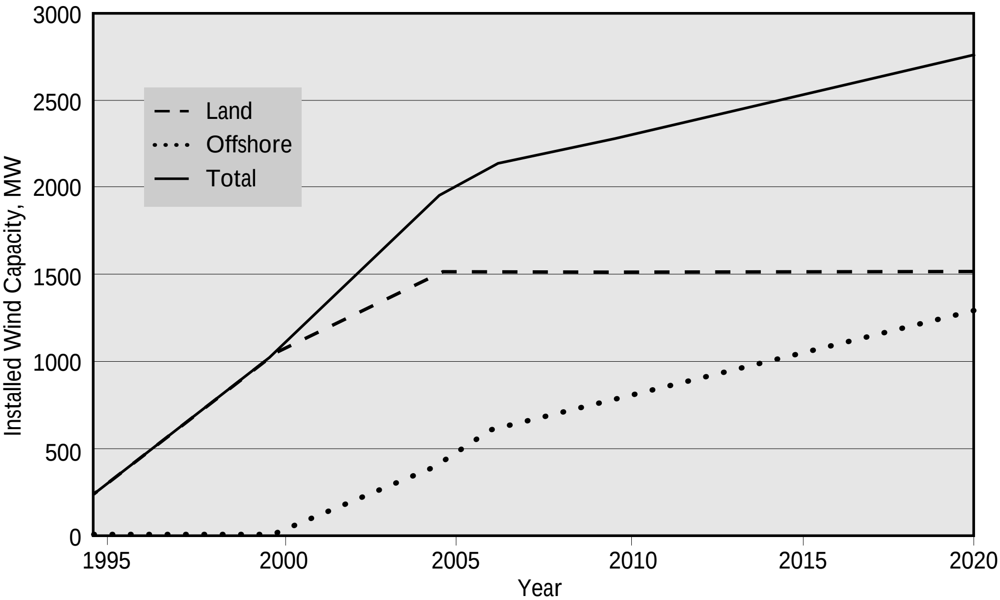

Figure 17.1 Expected Wind Capacity 1995–2020

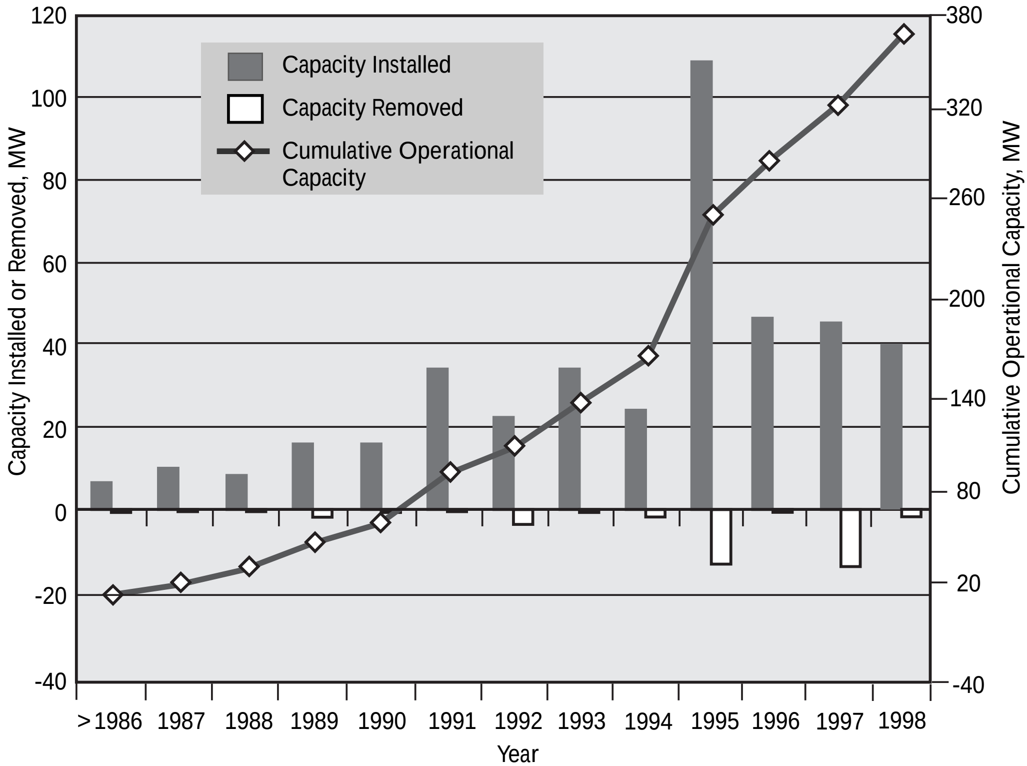

Figure 17.2 Installed, Removed, and Operational Wind Capacity

Removed were six Bouma wind turbines of 160 kW with a rotor diameter of 20 m and 1 Tacke TW600 wind turbine with a rotor diameter of 43 m.

17.2.3 Plant Types and Form of Plant Ownership

In 1998, one large wind farm was installed consisting of 19 wind turbines of 1 MW each. In addition, five small wind farms and 20 individual wind turbines were

Table 17.3 Distribution of New Wind Turbines by Manufacturer

MANUFACTURER	TURBINES	INSTALLED MW	INSTALLED %	ROTOR AREA m^2
NedWind	21	20.0	49	48,465
NEG-Micon	22	11.5	28	30,987
Vestas	10	5.7	14	14,989
Bonus	4	2.1	5	5,417
Enercon	3	1.5	4	3,770

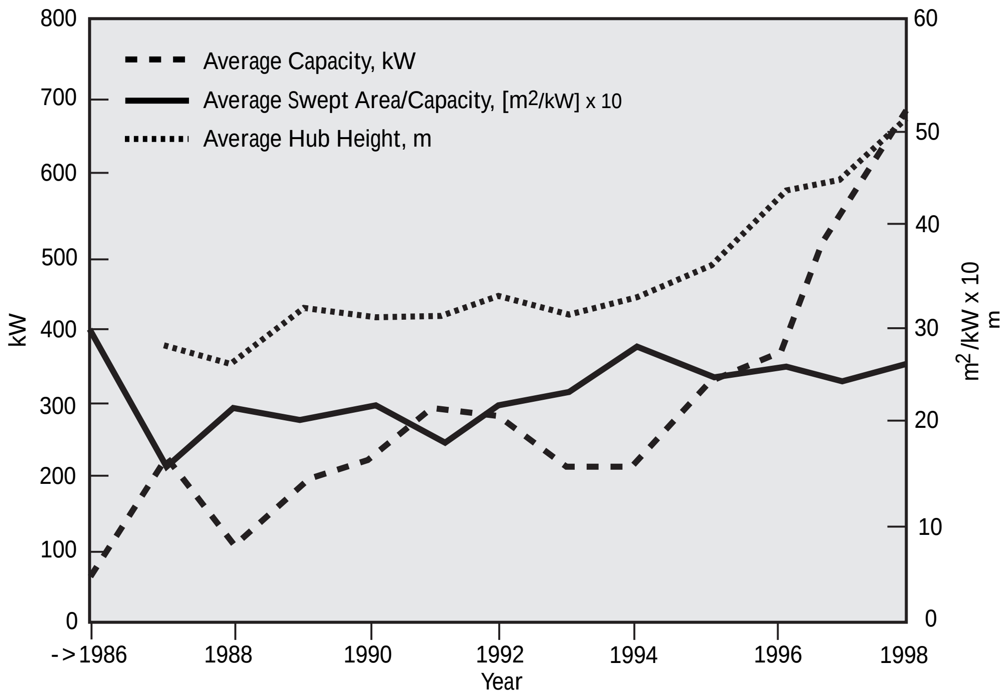

Figure 17.3 Average Capacity, Area / Power, and Hub Height of Installed Turbines in the Period 1986–1998

installed. The distribution is given in Table 17.4.

Of the installed wind turbines, 58% are owned by utilities and 42% are privately owned.

17.2.4 Performance of Installed Plants

Wind energy production in the period October 1997–September 1998, was 547 GWh. Average specific production in this period was 791 kWh / m^2. Total production in 1998 is estimated to be 700 GWh. This would avoid 6.1 PJ primary energy. Monthly energy production from wind energy can be found at the internet site http:// www.kema.nl

17.2.5 Installed Conventional Capacity And Electricity Consumption.

Installed conventional capacity in 1998 has not changed from 1997 and was around 18 GW, of which around 3.5 GW was in decentralized combined heat and power plants. Electricity consumption was 81,170 GWh in 1997. No numbers for 1998 are available.

17.2.6 Operational Experience

There were no major accidents or incidents in 1998.

17.3 MANUFACTURING INDUSTRY

17.3.1 Status / Number / Sales of Manufacturers

After the take-over of wind turbine manufacturer NedWind by NEG-Micon from Denmark and the demise of Windmaster, there are two Dutch wind turbine manufacturers.

There are also two Dutch blade manufacturers: Aerpac and Rotorline. Aerpac is established in Almelo and Haaksbergen in the Netherlands, but also

NAME OF WIND FARM	MANUFACTURER	HEIGHT	TURBINE	DIAMETER	CAPACITY	SWEPT AREA
Anna Palowna	NEG-Micon	46	8	43.0	4.800	11.618
Velsen	NEG-Micon	30	5	29.6	1.125	3.441
Lelystad	Enercon	55	2	40.0	1.000	2.513
Leeuwarden	NedWind	43	2	46.0	1.000	3.324
Zeewolde	NedWind	60	19	55.0	19.000	45.141
Dinteloord	Vestas	40	4	44.0	2.400	6.082
Various solitary turbines.	Danish/German		20	45.0	11.495	31.509

makes blades in Scotland and Spain. Aerpac employs about 170 people.

The total number of people who were employed directly by wind turbine and blade manufacturers in 1998 was about 300. It is estimated that another 680 are employed with subcontractors, consulting firms, service companies, research institutes and universities.

17.3.2 New Products / Technical Developments

In 1998, Dr. Gijs van Kuik was appointed as a new wind energy professor at the Delft University of Technology. In his inaugural speech, which he held on June 17, 1998, van Kuik highlighted different aspects of wind energy: social acceptance, industrial involvement, market issues, economics, wind energy implementation in the Netherlands and wind farms. He stressed that wind energy offers good opportunities.

Van Kuik is convinced that the Dutch wind industry should co-operate if they want to play a significant role in the world market. He therefore strongly supports the initiative of blade manufacturers, wind turbine manufacturers, engineering firms, and research institutes to co-operate in the development of future large offshore wind turbines. The development costs of such a 5-MW turbine, with a 3-MW demonstration version, are estimated at NLG 80 million.

The gearless, pitch-controlled Lagerwey 750-kW, 50-m diameter wind turbine with variable rotational speed was tested successfully and placed into production. The synchronous ring generator was designed in close co-operation with the Delft University of Technology.

17.3.3 Business Developments

In mid-1998, NEG-Micon from Denmark took over the Dutch wind turbine manufacturer NedWind. The companies expect that the combination will be able to gain a world market share of 20%. NedWind is convinced that, in today’s market, only large companies can survive, especially in the realization of offshore projects. The combined companies will work on development of offshore wind turbines. More than 25% of the total installed Dutch wind capacity was installed by either NedWind or NEG-Micon (formerly Micon and Nortank).

In a press release of August 17, 1998, the Dutch manufacturer of rotor blades, Aerpac, announced that they intended to take over the Dutch rotor blade manufacturer Rotorline from Heerhugowaard. However, by the end of the year, it appeared that the intended take-over caused more problems than expected, and therefore Aerpac abandoned the take-over.

In December 1998, Windmaster went bankrupt. However, the Dutch wind turbine manufacturer Lagerwey took over the bankrupt estate Windmaster Nederland in Lelystad and the shares of a number of her daughter companies. Also part of the staff went to Lagerwey. The main activities will be concentrated in Barneveld and project development in London. Lagerwey has decided to add to its own range of wind turbines (80 kW, 250 kW and 750 kW) to the 600-kW wind turbine of Windmaster. Lagerwey is to date the only wind turbine manufacturer, which is fully in Dutch hands.

17.3.4 Support Industries

Major banks and insurance companies are increasing their activities as a result of financing through the Green Funds. In 1998 the offshore industry started to show interest in participating with the preparations for large offshore wind farms.

17.4 ECONOMICS

17.4.1 Electricity Prices

The total rate of reimbursement is currently 15 to 16 NLG per kWh. See also Section 17.5.1 Market Stimulation Instruments.

17.4.2 Turbine / Project Costs

There are no statistical data available yet for the year 1998. We assume that prices have slightly fallen to a specific investment per kW installed capacity on average of 2,000 NLG / kW, plus or minus 20%. The specific investment per m^2 swept area averages 800 NLG / m^2. Turbine costs are still around 70% of total project costs.

17.4.3 Invested Capital

Based on the averages given in 17.4.2 the invested capital for 1998 was 82 million NLG.

17.5 MARKET DEVELOPMENT

17.5.1 Market Stimulation Instruments

For electricity from renewable energy generators the Dutch Ministry of Economic Affairs and the association of Dutch energy utilities EnergieNed have jointly laid down compensation regulations comprising three components. These have been in force since January 1, 1998 and are intended to stimulate the implementation of renewable energy.

1. Basic reimbursement

   The basic price is computed by taking into account the avoided purchasing prices of the energy provided by the distribution companies. Wind power reimbursement currently stand at 8.1 Dutch cents per kWh,

2. The Eco tax (CO_2 tax)

   After a tax reform, the consumer pays a surcharge of 2.95 Dutch cents for every kWh, with every household having a tax-free contingent of 800 kWh. The rate of the tax is set anew by the Dutch government every year and is directly collected by the energy provider. These additional funds then flow either into the state coffers, making tax breaks elsewhere possible, or are disbursed to the in-feeders of renewable energy,

3. Green Labels

   The energy distribution companies voluntarily committed themselves to supply 3.2% of electricity from renewables in the year 2000. About one-third of this amount is expected from wind energy, corresponding with 750 MW of installed capacity. To prove this, the companies have to show a corresponding amount of green labels. One label for 10,000 kWh is issued by the energy producer for the production of renewable energy. The labels can be freely sold by the owners, for example, by the operator of wind turbines. Currently they are trading at 5.2 Dutch cents per kWh. Most wind millers plan to guard against possible price fluctuations by long-term contracts over ten years. But the power company can itself produce eco-electricity and keep the corresponding labels itself. Trading of labels between utilities is also possible. A “stock exchange” was set up by the association of distribution utilities in March 1998. Up to now is has not led to a fully transparent market and much of the trading has been done outside the exchange. (Information available at http:// www.groenlabel.nl).

Other market incentives are related to reduced tax payments by companies. For a more detailed account on the Energy Investment Deduction Scheme, the Accelerated Depreciation on Environmental Investment Scheme, and the Green Funds see the *IEA Wind Energy Annual Report 1997*.

Figure 17.4 Windfarm Moerdijk is seen over the estuary Hollands Diep against a background of petrochemical plants. The turbines are NedWind 1 MW, 55-meter diameter on a 70-meter mast.

Various energy distribution companies started green pricing. They offer their customers green, nature, or eco-electricity. Customers can voluntarily buy all or a share of their annual electricity consumption as green electricity at a 5 to 8 cents higher-than-normal price. The CO_2 tax is included in this price. Green pricing proved to be very successful in 1998.

17.5.2 Financing

There is an abundance of capital available through the Green Funds. Green funds of the three major banks are competing to invest in wind energy projects with low interest rates. The green interest in 1998 was 3 to 5%, depending on the term of the loan—2, 5, or 10 years. Average interest rates on the regular capital market in 1998 were 4.5 to 7%. All non-utility investors in wind energy finance their projects through the Green Funds. Utilities finance their investments from their own cash flow and calculate with an internal rate of return of 5%.

17.5.3 Planning and Grid Issues

The newly installed capacity has dropped dramatically since 1996, mainly because the development of sufficient sites with building permits for wind turbines is increasingly difficult.

To address the problem of the availability of sites, Novem started a national campaign, *Space for Wind Energy,* in 1997. It addresses primarily local decision-makers. In 1998 the campaign was intensified.

The backbone of the campaign is a series of products and services that can be used to assist local authorities to create space for wind energy. Some examples follow.

1. A quick scan to get a quick estimate of local wind energy potential. More than fifty local communities applied for a quick scan in 1998,
2. A detailed guideline for planning officials to help them incorporate wind energy in their physical planning schemes,
3. Excursions to wind farm sites,
4. Support to organize information meetings about wind energy in the municipality for the public and,
5. Process management support.

17.5.4 Institutional Factors

In 1997, the twelve (influential) provincial Environment Foundations and the (powerful) Foundation Nature and Environment published a common view and position on the role of wind energy in the Netherlands. It was seen as a major breakthrough, as their view is positive and pro-active.

In 1998, these foundations participated in the preparation for a 100-MW demonstration offshore wind farm by formulating their conditions for location, bird studies, and so forth. Moreover, they compiled a memorandum in which the issues are listed that should be addressed when starting wind farms offshore. It shows that these influential bodies are closely involved in the further development of wind energy in the Netherlands.

17.5.5 Impact of Wind Turbines on the Environment

Generally, in the Netherlands, it is felt that enough data has been collected on the impact of wind turbines on the environment, especially on birds. These data, however, only concern inland sites. Hardly any off-shore data are available. Because of the plans to develop wind farms near shore and offshore, some studies into the possible impact of wind turbines offshore on the maritime environment were started in 1998. Especially interesting is the project of radar tracking birds 10 kilometers outside of the coast of Ijmuiden with equipment of the Ministry of Defense.

17.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

17.6.1 Funding Levels

As a result of the R, D&D policy laid out in the action plan *Renewable Energy on the March*, the Novem budget for the wind energy programme (TWIN-2) was raised from 9 million NLG in 1996 to 14.1 million NLG for the years 1997 to1998 and to 16 million NLG for 1999 to 2000.

17.6.2 Priorities

The *Netherlands R&D-Strategy Wind Energy*, formerly the NRW-plan, has been revised for the period 1999–2003. The workshop during which the strategy was discussed was attended by representatives of wind turbine and blade manufacturers, engineering firms, end users (utilities, insurance companies, and certifying institutes) and the program managers ECN, TU Delft and Novem. Priorities for 30 R, D&D areas were set. The strategy will be the basis for the research programs in 1999 and 2000 of ECN, TU Delft and Novem.

The priority subjects are the following.

1. New developments: Offshore, Innovative materials and recycling,
2. Testing and measuring: Condition-monitoring systems, wind turbine test facilities,
3. Databases: Failure statistics of wind turbines and components,
4. Design tools: Reliability, wind turbines, control, aerodynamics.

17.6.3 New Concepts

A Joule project coordinated by the Delft University of Technology was completed in 1998: *Structural and Economic Optimization of Bottom-Mounted Offshore Wind Energy Converters (Opti-OWECS)*. It was the particular mission of the project to extend the state-of-the-art, to determine required methods and to demonstrate practical solutions, which will significantly reduce the electricity cost. This should facilitate the exploitation of true offshore sites on a commercial basis in a medium time scale of five to ten years from now.

In several fields, such as support structure design, installation of the offshore wind energy converters, operation and maintenance, dynamics of the entire offshore wind energy converter, structural reliability considerations, etc. The study demonstrated new propositions which will contribute significantly to a mature offshore wind energy technology. The project was carried out by a consortium of leading industrial engineers and researchers from the wind energy field, offshore technology and power management.

An innovative design methodology devoted particularly to offshore wind energy conversion systems was developed and successfully demonstrated. The so-called integrated OWECS design approach considers the components of an offshore wind farm as part of an entire system. Therefore interactions between sub-systems are considered in as complete and practical a form as possible so that the design solution is governed by overall criteria, such as levelized production costs, adaptation to the actual site conditions, dynamics of the entire system, installation effort as well as OWECS availability.

Also, a novel OWECS cost model was developed, which led to the identification of the main cost drivers, such as annual mean wind speed, distance from shore, and operation and maintenance aspects, including wind turbine reliability and availability. A link between these results and a database of the offshore wind energy potential in Europe, developed in a previous Joule project, facilitated the first consistent estimate of energy cost over entire regions of Northern Europe.

17.6.4 MW-rated Turbines

The second NedWind 52.6 m, 1-MW wind turbine built on the existing tower of the NEWECS-45 at Medemblik produced 2.04 GWh in the period from October 1997 through September 1998. The specific production was 939 kWh / m^2. Another 19 NedWind 1-MW wind turbines were installed at Zeewolde in November 1998. No production data are available yet.

17.6.5 Offshore Developments

Maximum wind capacity for land-based sites is estimated to be around 1,500 MW in 2005 to 2010. The national goal is 2,750 MW in 2020. It is believed that the 1,250 remaining MW can be realized with offshore installations. Therefore several studies are being carried out, focusing on implementation of wind turbines offshore.

In 1997, Novem carried out a feasibility study into a 100-MW near-shore wind farm. It concerns a demonstration project and aims at gaining experience and knowledge of offshore installation, construction and operation. See *IEA Wind Energy Annual Report 1997*. Preparatory activities started in 1998 mainly concern legal and administrative procedures. The government has decided to choose the location in a clear and careful manner. Therefore the procedure of the *Planological Core Decision* is being followed. This is a step-by-step procedure of public enquiries and decision making. The procedure started in July 1998 with the publication of a memorandum. At the same time, the procedure of the *Environmental Effect Report* was started. In September, public hearings were held to discuss aspects like energy, biotic and abiotic environment, landscape safety, use of space, economy, and technology. Speakers were not only from the Ministry of Economic Affairs, but also from the foundation, Nature and Environment, which supports the demonstration project. The Dutch parliament has to agree to the location, which is going to be selected. Actual building of the 100-MW wind farm is expected to start in 2001.

For the longer term, Novem has carried out a preliminary feasibility study into the possibilities of offshore wind farms, more than 20 km from the Dutch coast. The study has resulted in a *Planning Scheme for Offshore Wind Energy*, and it shows that there is still a long way to go before the first wind farm far offshore can be installed. The administrative and legal procedures will take a long time, mainly because legislation on offshore wind farms is currently lacking. In 1999 the first steps will be taken toward building the first far offshore wind farm in 2005.

Proposals for a 300-MW wind farm along the 32-km Afsluitdijk connecting the Dutch provinces Friesland and North Holland have been approved by the Friesian Provincial Council, bringing the ambitious plans one step nearer to realization. The scheme was launched last year by the utilities NUON and ENW.

17.6.6 International Collaboration

For a detailed list of projects see the *IEA Wind Energy Annual Report 1996.*